MANUAL OF

STANDARD PRACTICE

FOR THE

POWER-LAUNDRY WASHROOM

(SECOND EDITION)

[illegible] YOWNERS' NATIONAL ASSOCIATION
[illegible], ILLINOIS

MANUAL OF

STANDARD PRACTICE

FOR THE

POWER-LAUNDRY WASHROOM

(SECOND EDITION)

By

THE DEPARTMENT OF RESEARCH
of the
LAUNDRYOWNERS NATIONAL ASSOCIATION
Mellon Institute of Industrial Research
of the University of Pittsburgh

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Foreword

THE following pages are intended to present in logical order a complete report, to date, of the research work on washing technology of our Department of Research, which is maintained by the L. N. A. in the interest of our membership, at Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

It must not be considered that this is a report of all the work done in this field of laundry practice, but it is a report of the principal results of that work.

Most of this matter has been presented previously in another form, but our experience is that much of these valuable data has been lost or mislaid and that there is a growing demand for the reissuing of these reports in better and more convenient form.

To the member who is a student of his business, the writer most earnestly recommends a careful reading of the following chapters. Each chapter covers one phase of the washroom and the one chapter gives standard formulas for washroom practice.

These formulas must be used to produce results, both in quality of work and economy of production methods. The intelligent use of them requires a careful study of the following pages.

Your National Association has secured the information for you, and now, dear members, it is up to you to take and apply it.

Many of our members are most enthusiastic over the results obtained through the application of this information to their washroom production methods. They say they are getting a better and more uniform quality of work, with a material saving in time and supplies; an end, we feel sure, that is well worth striving for.

Let us repeat again that to cash in on this information, it must be made use of.

No laundryowner likes to be called ignorant; and yet when one does not constantly consider all the available knowledge that directly applies to the quality of his product, the economy of production, and the conservation of the life of the goods entrusted to his care by his patrons, he is practicing indifference, which is one form of ignorance.

The writer is frequently called upon to defend the good name of the laundry industry when it has been or is being assailed by cartoonists, jokesmiths, and other well-meaning but ill-advised newspaper and magazine writers. In these cases he always refers with pride to the fact that the Laundryowners National Association maintains a Department of Research in Mellon Institute and that this Department is in the interest of laundry patrons as much as it is in the interest of laundryowners.

And so, then, let us study diligently the following pages. Let us not try to absorb the entire report in one, or one dozen readings, but let us consider this report in the light of an encyclopedia of washroom information—something that we want to have located conveniently, where we can consult it frequently; and remembering always that it is the result of eight years of careful and scientific investigation into the most vital part of our business.

Let it not be said that any member of the L. N. A. is so indifferent to his future prosperity and progress, or so disinterested in the good name of our industry, as to permit himself to glance over these pages carelessly and throw them aside with the thought that they are not for him.

None of us have as yet graduated from the great school of experience. We all have a great deal more to learn about this business of ours, which is perhaps one of the most intricate and trying businesses in the world.

Your National Association is interested in helping you and every other member of this great fraternity of ours.

Our Department of Research, like all of our other service departments, is an unbiased institution. It is looking for the truth. It has nothing to sell you. It is not interested in the sale of one thing any more than it is of another. What it tells you is the exact truth about the nature of the supplies that are offered for sale to laundries, as to their effect on the goods, as to the effect on your pocket-book, and as to the quality of your product.

The information given out is as nearly correct as science and research can make it. In science and in research every factor receives its full share of consideration. The work is not merely theoretical but is practical as well. Science is organized knowledge and classified common sense. The word is not something to be afraid of but rather something to be cultivated. When we are sick we get a doctor. He is a scientist; we are not afraid of him, but we have confidence in him and his work. We place our lives in his hands without hesitation. We wouldn't think of getting a "practical" doctor, or dentist, or even a practical veterinary for our sick animals. We make use of science in our every-day life, in hundreds of different ways, so why should we shy at it when it comes along to help us with our business problems.

Indifference is the rock upon which many a business has been wrecked. The proprietor or manager of a laundry is like the captain of a ship. He must see to it that the rocks of indifference and carelessness are

avoided. New rocks are continually getting in the way of progress in the laundry business, and it is getting to be the thoughtful, the careful, the studious and the progressive men in ours and every other line of business, who will weather the storm, avoid the rocks and sail their ships of business into the harbor of true and worthy success.

And so, dear member, your National Association sends their valuable information to you. Read it—read it some more; apply it—apply it some more; think of it—think of it some more; profit by it—profit by it some more; and above all things, remember that everything in the following pages is written first, in your interest; second, in the interest of your patrons; and third and last, in the general interest and welfare of the laundry industry as a whole.

And, finally, remember that the very last paragraph of Chapter XIII in this book contains a very important statement. It is, in fact, the reward for a duty well done. That you may qualify for this endorsement is the earnest hope of

Yours very truly,

LAUNDRYOWNERS NATIONAL ASSOCIATION,

Per W. E. Fitch,
Vice-President and Manager

Preface

IN THE preparation of the second edition of the "Washroom Manual" the object of the Department of Research has been twofold. The first aim has been to have the enlarged edition serve as a practical guide to those actively interested in power-laundry operation and the second, to satisfy a growing demand for a suitable text-book for the student engaged in the study of laundry chemistry.

A number of new chapters have been incorporated in the volume, while obsolete information has been omitted. An effort has been made to prepare a book of practical value to all who are interested intimately in the industry. All recommendations are based on authoritative information derived from research work conducted by the Department of Research of the Laundryowners National Association at Mellon Institute or from accepted chemical literature.

The book is respectfully submitted with the hope that it will prove of real value to the industry.

DEPARTMENT OF RESEARCH
LAUNDRYOWNERS NATIONAL ASSOCIATION.

Mellon Institute of Industrial Research
University of Pittsburgh
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CHAPTER I

WATER

Of all the materials abundant in nature, water is most essential to animal and vegetable life. It is also industrially a most important substance, and in no industry does its quality affect the operating processes more than it does in laundering textile fabrics. While water is abundantly distributed, it never occurs in nature in a pure state. Its nearest approach to purity in nature is found in fresh rain water. In natural waters, in lakes, rivers, wells and springs there are always in solution in greater or smaller quantities various substances whose presence influences the properties of the waters. The most common of these substances are carbon dioxide (a gas absorbed from the air); various salts of sodium, such as sodium chloride, or common salt; sodium sulfate, or Glauber's salt; calcium salts, such as calcium bicarbonate, which on losing carbon dioxide forms chalk or a material in composition similar to limestone; calcium sulfate, or gypsum; and compounds of iron, aluminum and magnesium.

The presence of sodium salts in moderate amounts does not impair the value of water for laundry uses. Calcium, magnesium and iron compounds, however, are objectionable for several reasons. The quantity of these and more rarely of some other elements, is what determines the degree of hardness of water. It is, indeed, due to the effect of these elements on soap solutions that the expression "hard water" has been coined.

Definition of Hardness.—Since 111 grains of calcium chloride, 136 grains of calcium sulfate, 84 grains of mag-

nesium carbonate, 94 grains of magnesium chloride or 119 grains of magnesium sulfate will decompose as much soap as will 100 grains of calcium carbonate, the custom is established in American engineering practice to calculate all these compounds in a water in terms of their equivalent amounts of calcium carbonate. Hence, a degree of hardness in American practice means the presence of these soap-destroying compounds in an amount equivalent to one grain of calcium carbonate per U. S. gallon.

A water of three grains or less of hardness is a *soft* water; water containing from three to six grains is *moderately hard;* and one containing from six to eighteen grains is *hard.* Hardness above eighteen grains per gallon stamps a water as being *very hard.*

For the sake of the discussion that is to follow, it is to be understood that hardness due to the bicarbonates of calcium, magnesium and iron, is known as *temporary hardness* and that caused by the sulfates and chlorides of these elements is known as *permanent hardness.*

Why a Soft Water is Desirable.—The reasons why a soft water is required for satisfactory laundering are almost too obvious to be discussed, but a few of them will be enumerated. As has been suggested above, calcium, magnesium, iron and heavy metal compounds react with common soap to form insoluble sticky substances. This reaction not only renders a portion of the soap added to the washing bath ineffective as a detergent, but, at the same time, produces additional material to be emulsified by the remaining sodium soap. Some of the calcium and magnesium soap is deposited in the fabric and is not easily removed. In the suds-bath most of the objectionable insoluble soap can be kept in an emulsified form, in much the same way that globules of fat are suspended in milk. In the rinsing bath, however, con-

ditions are changed and most of the insoluble soap along with the suspended dirt is deposited. This is sometimes precipitated on the fabrics evenly, producing gray, dingy work, or is deposited in globules, causing so-called "soap specks." These facts are so thoroughly established and so generally understood that they will be accepted without further comment as at least qualitatively true. Some modifying conditions will be noted later.

Under What Conditions is a Water Softener Needed?—The reaction that takes place when soap is added to hard water may be pictured by the following expression:

$$\underset{\text{(Sodium oleate or soap)}}{2C_{17}H_{33}COO.Na} + \underset{\text{(Calcium bicarbonate)}}{Ca(HCO_3)_2} \rightleftharpoons \underset{\text{(Calcium oleate or lime soap)}}{(C_{17}H_{33}COO)_2Ca} + \underset{\text{(Sodium bicarbonate)}}{2NaHCO_3}.$$

(Equals reversibly)

Whether this reaction takes place from left to right, in the direction of the top arrow, or from right to left, in the direction of the bottom arrow, depends on the relative amounts of the sodium and the calcium compounds present. This principle is known in physical chemistry as the law of mass action. With a water of six grains of hardness or less, a condition usually existing in the washing machine, the reaction will take place largely from left to right and the objectionable calcium soap will be formed. The extent to which the reaction proceeds can be controlled in a measure by adding certain amounts of a soda to the suds bath and to the first rinse following the suds bath. One commercial method of making soap may be cited as an example of the reaction taking place from right to left, that is, in the direction of the bottom arrow. Fats are treated with calcium hydroxide (slaked lime), forming glycerin and insoluble calcium soap that is easily separated from the glycerin and water. The calcium soap is then treated with soda ash, forming sodium soap (common soap) and calcium carbonate, which is insoluble and can be readily separated from the

soap. The reaction is represented by the expression on page 3, reading from right to left. This example is given to show that the reasoning about to be presented is not based solely on laboratory evidence.

To answer specifically the question, "How hard may a water be before a softener is needed for a laundry supply?" is rather difficult. Evidence is presented here, however, to fix the limits in a general way. A water of natural hardness of 3.7 grains was experimented with. This water, cold and without any alkali, decomposed 1.89 pounds of (88.0 per cent.) commercial soap per 1,000 gallons. This same water, hot, plus 0.11 of a grain of soda ash per gallon, used 0.76 of a pound (approximately 12 ounces) of the same soap per 1,000 gallons. Pure distilled water will consume four ounces of this soap per 1,000 gallons. Therefore, the saving in soap to be effected by softening this water to zero degree hardness would be only about eight ounces per 1,000 gallons. It should be noted that this saving would be effected only with the water used in the suds bath and not with the total water used in the plant.

From the considerations noted in the foregoing paragraphs, the conclusion would logically follow that, given a natural water of not over four grains per U.S. gallon in hardness, the installation of a water-softening system would not be a commercial success on a strict basis of washroom economy. This conclusion is rendered more emphatic in the case wherein most of the four grains of hardness is temporary hardness. This statement will be more clearly understood if the reader bears in mind the fact that most of the temporary hardness may be removed by heating the water, and that most of the water wherein soap is used in the laundry is or should be hot water.

These observations have been confirmed in at least one installation of a "zeolite" softener. The natural

water for which the installation was made had a seasonal maximum hardness of about four grains, more than half of which was temporary hardness. It was found upon the L.N.A. cost system record that the operation of the softener on this particular water did not pay.

It is, therefore, the opinion of the Department of Research that a water supply for laundry purposes should have an average hardness of three grains and a maximum hardness of four grains per U.S. gallon before the need of a water softener becomes imperative.

What Kind of a Softening Plant is Desirable?—Having decided in a specific instance that the installation of a water-softening plant is desirable, the next decision concerns the choice of one of the two general types of softener for the particular set of conditions.

The commercial systems now available may be divided into two general types: the one will be called the lime-soda ash type and the other the zeolite-filter type.

Lime-Soda Ash Type of Softener.—Under the type designated lime-soda ash, taking its name from the most commonly used softening agents, are those actually employing these reagents and others employing different reagents that possess similar chemical characteristics.

The lime-soda ash system proper for cold water softening has had the approval of engineering practice for a number of years. The success of this system depends on the fact that, when lime and soda-ash are added to hard water in proper proportions and amounts, free acids are neutralized, free carbon dioxide is removed, the bicarbonates are decomposed, and iron, aluminum and magnesium hydroxides and calcium carbonate are precipitated. Because of the principle of mass action, previously referred to, it is impossible to remove completely these elements from the water by this method. Also, if more lime is added than is required, the hardness is increased unless additional soda ash is added to precipitate this excess of

lime. The excess of these reagents increases the alkalinity of the treated water. It is therefore important to add just the proper amount of lime to remove the acidity, temporary hardness, iron, aluminum and magnesium, and of soda ash to take care of the permanent hardness of a given hard water. It is impracticable to bring the treated water below the equivalent of 3 to 5 grains of calcium carbonate per U. S. gallon.

Other reagents besides lime and soda ash have been used to precipitate the hardening compounds in natural water. Among these are caustic soda, sodium silicate, borax, and trisodium phosphate, but lime and soda ash are used almost exclusively on account of their excellent action and comparative cheapness. Only one of the others, caustic soda, will be discussed later.

By suitable mechanical arrangements, the precipitating reagents are added and thoroughly mixed with the raw water; the precipitates are allowed sufficient time to settle and are then removed from the water by filtration.

The rate at which the chemical reactions take place and the existing conditions influence the physical form of the precipitates, affecting their solubility and the effectiveness of the filtering process, and hence are factors entering into the control of the residual hardness of the treated water. Thus it is of utmost importance that time be allowed for the completion of the reaction, which at best proceeds rather slowly. To care for all these requirements, two methods of procedure are employed.

Continuous.—One method is the continuous process, in which the proper quantities of softening agents are mixed continuously with the inflowing raw water. The water then passes into a large reservoir of suitable shape and of sufficient capacity to allow time for the reaction to go to completion and for the precipitate to settle before the

water reaches the filter-bed. The softened water flows to a reservoir and thence to the service pipe.

Intermittent.—The other method is the intermittent process, in which two or more tanks are provided. One tank is filled with raw water, and the calculated amounts of softening agents are added and thoroughly mixed by some form of mechanical stirrer or by compressed air. The solids formed are then allowed to settle, while previously treated and settled water is used, through the filter, from the other tank.

The continuous method has, among other advantages, that of requiring less space for a given capacity, while the intermittent method has the advantage of simpler mechanical construction.

Caustic Soda Treatment, Using Four-way Piping System.—A raw water, in which the equivalent amount of temporary or bicarbonate hardness is equal to or exceeds the permanent or sulfate and chloride hardness, may be treated with caustic soda. The reactions are similar to those taking place with lime and soda ash, with this exception, which is of practical importance: with caustic soda, soluble salts, equivalent to a part of the compounds causing hardness in the raw water, remain in the treated water if the required amount of caustic soda is used. In the lime and soda ash treatment, the soluble salts may be reduced because all the resulting salts of the reaction with the temporary hardness are insoluble. The following picture will illustrate these conditions:

Temporary Hardness Treated with Lime

$Ca(HCO_3)_2$	+	$Ca(OH)_2$	$\rightleftharpoons$	$2CaCO_3$	+	$2H_2O$.
Calcium bicarbonate		Slaked lime	Equals reversibly	Calcium carbonate (insoluble)		Water

Temporary Hardness Removed with Caustic Soda

$Ca(HCO_3)_2$	+	$2NaOH$	$\rightleftharpoons$	$CaCO_3$	+	Na_2CO_3	+	$2H_2O$.
Calcium bicarbonate		Caustic soda	Equals reversibly	Calcium carbonate (insoluble)		Sodium carbonate or soda ash (soluble)		Water

Some of the sodium carbonate so formed reacts with the permanent hardness and is changed to sodium sulfate that remains in solution:

$CaSO_4$	+	Na_2CO_3	=	$CaCO_3$	+	Na_2SO_4
Calcium sulfate		Sodium carbonate	Equals	Calcium carbonate (insoluble)		Sodium sulfate (soluble)

If there is not enough permanent hardness to react with all the sodium carbonate, the alkalinity of the treated water is high; hence the necessity of having the four-way piping system to provide raw water for final rinses. On the other hand, if there is not sufficient sodium carbonate formed from the temporary hardness, some of the permanent hardness is not removed. It is evident from this reasoning that this method of water softening has a limited application. Caustic soda is more expensive than lime and soda ash and the caustic soda method has only the apparent advantage that, if the hardening compounds of a raw water occur in a certain ratio and if an excess of reagent is used, a zero water may be had.

Zeolite Type.—The zeolites are naturally-occurring minerals, similar to feldspars in composition, except that they are hydrated; that is, they have the elements of water in their composition. The chemical composition of a typical one, "stilbite," is represented by the following expression:

$$H_2(Na_2Ca)\ Al_2\ (SiO_3)_8\ .\ 4H_2O.$$

The proportion of the sodium to calcium varies and, in some, potassium appears instead of sodium.

Artificial zeolites may be made by properly treating a certain mixture of clay, feldspar, sand and soda ash. They are practically insoluble in water and it is largely upon this property that their efficacy as water-softeners depends. The sodium or potassium of the zeolites reacts with the calcium and magnesium of the water, the result

being a softened water. For instance, if a water containing 13.6 grains of calcium sulfate per U. S. gallon were passed through a properly prepared zeolite filter at a sufficiently slow rate of flow, it would then contain 14.2 grains of sodium sulfate per U. S. gallon. The calcium of the calcium sulfate would be left on the zeolite as an insoluble calcium zeolite, the sulfate being combined with the sodium. Letting R stand for the complex silicate or zeolite portion of the filter material, the reactions may be represented by the following equations:

Sulfate and Chloride Hardness

(Permanent Hardness)

Na_2R	+	$CaSO_4$	=	Na_2SO_4	+	CaR.
Zeolite		Calcium sulfate	Equals	Sodium sulfate		Calcium zeolite

Likewise for calcium chloride:

NaR_2	+	$CaCl_2$	=	2NaC1	+	CaR.
Zeolite		Calcium chloride	Equals	Common salt		Calcium zeolite

(Temporary Hardness)

Na_2R	+	$Ca(HCO_3)_2$	=	$2NaHCO_3$	+	CaR.
Zeolite		Calcium bicarbonate	Equals	Sodium bicarbonate		Calcium zeolite

These equations show how the Ca (calcium) of the hard water changes place with the Na (sodium) of the zeolite during the operation of softening.

The point to be observed is that for each equivalent of calcium or magnesium in their respective compounds in hard water that is removed by this softening process, there must go into solution an equivalent of sodium or potassium compounds, as the case may be.

Sodium and potassium carbonates, chlorides and sulfates constitute the compounds sometimes called the "foaming constituents" of boiler feed water. In concentrations likely to be encountered, they are not apt to be found objectionable either in the steam boiler or in the washing machine.

Another factor which is likely to cause foaming in boilers is the presence of undissolved particles of matter, such as may result from the separation, from the inside of the boiler, of incrustations that were deposited through the use of hard water. Boiler scale is usually acted upon by water that has been softened by the zeolite process. A part of the scale may be dissolved and the remainder floats about in the boiler water. These suspended solids together with the dissolved materials greatly increase the tendency of the boiler to foam.

If a change is made from the use of hard water to zeolite-softened water, it is essential to clean out the boiler once each week until the old scale has been completely removed. After this has been done, the boiler will require no further attention in so far as scale is concerned.

The concentration of sodium bicarbonate resulting from treating a water high in temporary hardness by this process may sometimes prove a disadvantage in souring and bluing. By boiling sodium bicarbonate solution, a large portion of the sodium bicarbonate is converted into the normal carbonate or soda ash, with the loss of carbon dioxide. The presence of too much soda in the rinse following the bluing bath would have a bad effect, as is well known, on basic aniline blue. For this reason, a raw water of 10 grains or more of temporary hardness (permanent hardness does no harm here) treated by this process would in some cases require modified procedure in the washing formula after the sour bath.

By a well-established law of physical chemistry, the law of mass action, repeatedly referred to, it is known that whether the reactions pictured above proceed in one direction or the other depends on the concentration of the reacting substances. When the water being treated

passes through, the concentration of the Na_2R or sodium portion of the zeolite is so much in excess, that the reaction goes practically to completion in the direction indicated by the top arrows, and there is had, as a result, soft water. After a time this condition no longer obtains and the Na_2R must again be restored. This is done by passing through the zeolite a strong salt solution, the salt being in such an excess that the reaction takes place in the direction of the lower arrows, and the filter is regenerated. By the same reasoning, a raw water high in sodium salts cannot be successfully treated by this process.

The four-way caustic-soda system is practically obsolete, and the discussion of it is left in the present edition of this treatise largely as a matter of complete record. A great disadvantage in its use in the laundry lay in the temptation which the hard water connection to the washing machine presented to the operator to use hard water for rinsing. As far as the appearance of the laundry work is concerned, it is more important to have soft water for rinsing than in the suds baths. The object of rinsing following the suds bath is obviously to remove the soap and the dirt held in suspension. The use of hard water precipitates the soap and leaves much of it in the fabrics. The only excuse for the hard water connections lay in the fact that the alkalinity of the water softened by this method is to be avoided in the souring and bluing baths.

Combination Lime and Zeolite Installations.—There are some waters, the hardness of which consists mainly of calcium bicarbonate, that may be softened by the use of lime alone. If such a water is treated with lime alone, the alkalinity will be removed as well as the hardness and at a cost much less than would result from the use of a "zeolite" softener.

Muddy waters require prefiltering if they are to be softened by a "zeolite" softener.

Waters carrying appreciable quantities of iron compounds must be pretreated in one way or another before they can be successfully treated with a "zeolite" softener.

Waters high in carbonic acid or other acids cause rapid deterioration of the "zeolite" and in a number of instances waters of this character, when treated with the "zeolite" softener, have been the cause of excessive pipe corrosion and rusty water troubles in the laundry. With an open type of water heater this difficulty would have been ameliorated, but more economically by the employment of a lime treatment ahead of the "zeolite" treatment.

It is therefore advisable in treating water supplies characterized by any or all of the conditions just enumerated to consider the expediency of installing a lime softener in conjunction with the "zeolite" softener. The various firms having the "zeolite" systems for sale are equipped to handle the engineering problems in connection with such an installation. The following advantages of such installation are: (a) the alkalinity of the treated water will be reduced; (b) the turbidity or mud will be removed; (c) iron will be removed; and (d) the likelihood of red water in the pipe lines will be eliminated.

The Most Desirable Type of Softener for the Laundry.—It is only fair to say in summing up this discussion of water softeners that, in general, the "zeolite" type of softener is best adapted to laundry purposes. It has, on a water not too high in temporary hardness and free of the conditions enumerated above, the decided advantages of simplicity of construction, ease of operation, requiring little chemical control, and, provided it is of sufficient capacity to care for seasonal variation of the hardness of the water supply, absolute dependability. For the reason suggested in the last clause no water-softening installation should be made on the analysis of

one water sample. Most city water-works keep a record of the seasonal variation. These data should be secured in addition to those obtained by the analysis of a special sample. If such a record is not available, sufficient capacity should be estimated to adequately care for the season of maximum hardness as well as for additional requirements entailed by the growth of business.

However, when properly operated, the lime-soda ash type of softener gives excellent results and in some cases, as already indicated, is to be preferred to the "zeolite" type.

Sampling of Water.—A member in presenting his water-softening problem should, along with data as to maximum daily volume of softened water required, available space for the installation and permanency of the installation proposed, send a representative sample of the raw water to be treated. If the water is from a new well, it should be pumped for several days before taking the sample. If it is from an old well, the water should be pumped until the fresh water is flowing. Likewise, if it is a city water supply, the faucet should be opened and the water run to waste for a few minutes. The sample should then be taken in a clean glass container of at least one-gallon capacity; a one-gallon glass vinegar jug is suitable. The container should be rinsed out several times with the water being sampled, and then filled to overflowing and the water in the mouth displaced with a clean stopper which should be fastened securely. These detailed precautions should be observed. A salt-glazed jug or common stoneware often affects the alkalinity, and, consequently, the hardness of the water sample contained in it, and thus spoils the sample. Such jugs should not be used.

EXPERIMENTAL PART FOR STUDENT

Make a CO_2 (carbon dioxide) generator by placing about 50 grams of chipped marble ($CaCO_3$) and 100 c.c. of water in a 500 c.c. round-bottom flask, mounted over a gas burner. Through a dropping funnel, the lower end of which extends below the surface of the water in the flask, add, drop by drop, some concentrated hydrochloric acid (HCl):

$$CaCO_3 + 2\ HCl + H_2O = CaCl_2 + 2H_2O + CO_2$$

Carbon dioxide is generated, which by gentle heating of the solution is expelled and may be bubbled through lime water, prepared as follows:

Boil a mixture of slaked lime and water, and allow the solution to stand until the undissolved lime has settled. The clear solution above the solid will contain some lime. Pour off a part of this solution into a beaker and pass the CO_2 through it.

Observation.—The clear solution of lime water will become cloudy at the beginning of the operation because the soluble calcium hydroxide [$Ca(OH)_2$] is converted into insoluble $CaCO_3$ (calcium carbonate): $Ca(OH)_2 + CO_2 + H_2O = CaCO_3 + 2H_2O$. As the CO_2 continues to go into the cloudy solution it again becomes clear because the $CaCO_3$ is converted to the more soluble bicarbonate [$Ca(HCO_3)_2$]:

$$CaCO_3 + 2\ H_2O + CO_2 = Ca\ (HCO_3)_2 + H_2O.$$

The solution now contains calcium bicarbonate [$Ca(HCO_3)_2$] and is a water of temporary hardness.

Test.—To about 150 c.c. of distilled water add a few c.c. of the water of temporary hardness. Shake the mixture thoroughly and then draw off two portions of 58.3 c.c. each. Boil one portion for about 5 minutes in a small flask, keeping the volume up to 58.3 c.c. by the addition of distilled water, and then filter.

The boiling treatment will cause the clear solution of calcium bicarbonate to become cloudy, due to the conversion of the soluble calcium bicarbonate into insoluble calcium carbonate: $Ca(HCO_3)_2 + H_2O + \text{heat} \rightarrow CaCO_3 + CO_2 + 2H_2O$.

Now test the boiled and the unboiled portions of water for hardness with the standard soap solution.

Explain the result obtained.

Repeat this test, using hard water that has been prepared by dissolving 1.11 grams of fused calcium chloride in one liter of distilled water, in place of the water containing calcium bicarbonate.

Explain the result obtained.

QUESTIONS TO BE ANSWERED

1. What is the difference between water of temporary hardness and water of permanent hardness?
2. How does boiling affect water of temporary hardness?
3. How does boiling affect water of permanent hardness?
4. Why are both soda ash and lime used for softening water?
5. What are the advantages of the zeolite water-softening system over the lime-soda ash system?

6. Should the lime-soda ash process ever be used in connection with the zeolite process?

7. When is it necessary to use a water softener in the commercial laundry?

ANALYTICAL NOTES

Determination of Hardness of Water by the Soap-test. [1]—The degree of hardness of a water is determined by ascertaining the amount of standard soap solution necessary to form a permanent lather with a definite volume of the sample; the "harder" the water the more soap it will consume, owing to the formation of insoluble calcium, magnesium, etc., soaps ("curd"), brought about by the decomposition of the soda or potash soap added, by the salts of the alkaline earth metals present in the water.

The hardness of water is usually expressed in terms of calcium carbonate.

Preparation of the standard solutions:

1. *Solution of "hard water."*—Dissolve 1.11 grams of pure fused calcium chloride in a little water and dilute to one liter at 15°C. Each cubic centimeter of the solution will correspond to 0.001 gram of calcium carbonate.

2. *Solution of soap.*—Castile soap, which is supposed to be made of soda and olive oil, is much used for standard soap solutions, but it has been found to be subject to considerable deterioration on keeping, especially in cold weather, owing to the deposition of sodium palmitate.

Sodium oleate makes a standard soap solution that suffers very little change on keeping and can be generally recommended for the purpose.

Thirteen grams of sodium oleate is dissolved in a mixture of 500 c.c. of alcohol and 500 c.c. of water and filtered if necessary. It now becomes necessary to standardize the solution, so that 1 c.c. will be equivalent to 0.001 gram of calcium carbonate. In order to do this, 12 c.c. of the standard hard water is run into a 250 c.c. stoppered bottle from a burette and diluted to 58.3 c.c. A burette is now filled with the soap solution, which is run into the bottle, 1c.c. at a time, and the bottle vigorously shaken after each addition, until a point is reached where a persistent lather, lasting for at least five minutes, is obtained. Note the volume required. Twelve c.c. of hard water should require 13 c.c. of the standard soap solution (distilled water itself requiring 1 c.c. to form a lather). The volume required in the above test will be less than this, usually because the soap solution prepared as directed is too strong and will require diluting so that 12 c.c. of a standard "hard" water will require 13 c.c. of the soap solution. An example of an actual preparation of a standard soap solution will explain this.

Thirteen grams of sodium oleate were dissolved in a mixture of 500 c.c. of alcohol and 500 c.c. of water and filtered. On testing in the manner prescribed, 12 c.c. of the standard "hard" water diluted to 58.3 c.c. required 11.4 c.c. of the soap solution to form a persistent lather.

Now, since 13 c.c. should have been required, every 11.4 c.c. of the soap solution remaining requires diluting by $13 - 11.4 = 1.6$ c.c.

[1] Method of H. Joshua Phillips, as found in Stillman's "Engineering Chemistry," p. 585.

Suppose there were 960 c.c. of the solution unused, therefore $\frac{960}{11.4}$ = 84.2, and $84.2 \times 1.6 = 134.7$ c.c. more of the mixture of alcohol and water to be added. On adding this quantity, thoroughly mixing, and testing as before, 12 c.c. of the standard hard water required exactly 13 c.c. of the soap solution.

Determination of Total Hardness.—58.3 c.c.[1] of the clear sample of the water to be examined are run into a 250 c.c. flask, and the standard soap solution added in the manner described above, until a lather capable of persisting for five minutes is produced. The number of cubic centimeters required will give the degrees of hardness in terms of calcium carbonate in grains per gallon.

Or take 100 c.c. of the water, transfer to a flask, and add standard soap solution as usual. Suppose that the 100 c.c. of water required 5.1 c.c. of soap solution. Then 1,000 c.c. of water would require 51 c.c. of soap solution, equivalent to 0.051 gram of calcium carbonate per liter, or 5.1 parts per 100,000, or 2.97 grains of calcium carbonate per United States gallon.

If the water contains a considerable proportion of magnesium salts, there will be some difficulty in obtaining the right end-point, owing to the slowness with which magnesium salts decompose soap; an apparently persistent lather is formed, which, on being allowed to stand a little while before shaking again, will disappear; a little experience with magnesian hard waters will familiarize the operator with this peculiarity.

Permanent Hardness.—Two hundred and fifty c.c. of the water are poured into a 500 c.c. flask, and boiled for one-half hour, the original volume being kept up by frequent additions of boiled distilled water, free from carbon dioxide.

After cooling, it is quickly poured into a 250 c.c., graduated, stoppered flask, diluted if necessary to exactly 250 c.c. at 15°C. with distilled water, well mixed and filtered. 58.3 c.c. of the solution are now poured into the bottle and the permanent hardness determined as described.

Temporary Hardness.—The temporary hardness, or that hardness removed by boiling, is obtained by deducting the degree of permanent hardness from that of the total.

Standards of Hardness. [2]—The French standard of hardness of water is stated in terms of milligrams of calcium carbonate in 100 grams of water, or parts of calcium carbonate per 100,000 parts of water.

The German standard represents milligrams of lime in 100 grams of water, or parts of lime (CaO) per 100,000 parts of water.

The English standard represents grains of calcium carbonate per Imperial gallon of 70,000 grains.

The American standard represents grains of calcium carbonate per U. S. gallon of 58,381 grains.

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[1] If it is desired to determine the hardness in grains per English Imperial gallon instead of the United States gallon, 70 c.c. of the water must be taken. This is dependent upon the fact that the English Imperial gallon contains 70,000 grains and the United States gallon 58,318 grains.

[2] Consult: "Some Recent Methods of Technical Water Analysis", by Prof. H. R. Proctor, *Journal of the Society of Chemical Industry*, January 12, 1904, pp. 8-11 (relates to the several methods of determination of hardness of water).

CONVERSION TABLE

Parts per	100,000	× 0.7	= Grains per Imperial gallon.
Parts per	1,000,000	× 0.07	= Grains per Imperial gallon.
Parts per	100,000	× 0.583	= Grains per U. S. gallon.
Parts per	1,000,000	× 0.058	= Grains per U. S. gallon.
Parts per	1,000,000	× 0.00833	= Avoir. pounds per 1,000 U. S. gal.
Grains per Imp. gal.		÷ 0.7	= Parts per 100,000.
Grains per Imp. gal.		÷ 0.07	= Parts per 1,000,000.
Grains per U.S. gal.		÷ 0.583	= Parts per 100,000.
Grains per U.S. gal.		÷ 0.058	= Parts per 1,000,000.

Reference: "Methods for Analysis of Water," U. S. Public Health Service, 1917.

CHAPTER II

ALKALIES

What Is an Alkali?—The term "alkali" is met with in every-day experience and as a consequence of the vague and different ideas that it expresses, the chemical significance is often obscure. For our purpose in the following discussions, we shall think of an alkali as any substance which, when dissolved in water, will make that solution have the following properties: A characteristic taste easily recognizable and usually described as brackish; a soapy feel to the fingers; it will turn red litmus paper blue and phenolphthalein pink; and it will neutralize an acid to form a salt.

All these properties are due to hydroxyl ions. The hydroxyl ion is obtained when the following compounds are dissolved in water:

Sodium hydroxide (caustic soda)	$NaOH$
Sodium carbonate (soda ash)	Na_2CO_3
Sodium carbonate monohydrate	$Na_2CO_3.H_2O$
Sodium carbonate decahydrate (sal soda)	$Na_2CO_3.\ 10H_2O$
Sodium sesquicarbonate (a neutral soda)	$Na_2CO_3.NaHCO_3.\ 2\ H_2O$
Trisodium phosphate	$Na_3PO_4.\ 12H_2O$
Disodium phosphate	$Na_2HPO_4.12H_2O$
Sodium borate (borax)	$Na_2B_4O_7.\ 10H_2O$

The molecule of sodium hydroxide, NaOH, when placed in water, splits up or ionizes thus:

$$NaOH \rightleftarrows Na^+ + OH^-$$

The sodium ion (Na) assumes a positive charge (+) while the hydroxyl ion (OH) assumes a negative charge (—). The alkalinity or causticity of any of the above washing agents depends upon their ability to form

hydroxyl ions. The arrows indicate that sodium hydroxide has a tendency to split into ions and that the ions have a tendency to reunite into undissociated NaOH, so that the equation represents an equilibrium.

The degree of ionization depends upon the concentration of the solution and upon the temperature. We are justified in assuming that, because of the very low concentration of the detergents in the wash-wheel and because of the fairly high temperature, ionization is practically complete for sodium hydroxide.

But where does the necessary OH come from to make soda ash fulfill the requirements of an alkali?

Soda ash in water solution first ionizes,

$$Na_2CO_3 \rightleftarrows 2\,Na^+ + CO_3^{--},$$

and then hydrolyzes—that is, it reacts with water (H_2O), which ionizes as follows:

$$H_2O \rightleftarrows H^+ + OH^-;$$
$$2Na^+ + CO_3^{--} + 2H^+ + 2OH^- \rightleftarrows 2Na^+ + 2OH^- + H_2CO_3.$$

One product of the hydrolysis is H_2CO_3, or carbonic acid. Another product is 2NaOH, or two molecules of sodium hydroxide. In this manner, soda ash indirectly yields hydroxyl ions in water solution.

It is interesting to note the difference between Na_2CO_3 and $NaHCO_3$ in the manner of ionization and hydrolysis:

$$NaHCO_3 \rightleftarrows Na^+ + HCO_3^-.$$

The HCO_3^- ion hydrolyzes only very slightly and therefore yields practically no OH^- ions. From the standpoint of a laundry soda, the bicarbonate is therefore of no value, except that it has a tendency to prevent hydrolysis of the soda ash and thereby prevents soda ash from exerting its full alkaline value when used to excess in the wash-wheel.

Before sodium phosphates or borax can act as alkalies, hydrolysis is necessary, also.

Whenever a comparison is to be made between any of the above-mentioned alkalies as to their value in the washroom, it should be done on the basis of the hydroxyl ion concentration of their solutions and not on the basis of their respective Na_2O contents.

It is possible to conceive of cases where the sodium phosphates or borax would remove stains from clothes where the sodium carbonates would fail, but such cases are to our knowledge exceedingly rare.

Why We Use an Alkali.—An entirely acceptable theory of the detergent action of soap solution is not as yet thoroughly established. There are, however, several observed facts that assist us in measuring the effectiveness of various solutions and comparing them. It has been proved, for instance, by simple experiments in the laboratory, that solutions of soda ash, borax or any of the common alkalies named above will not wash lamp black, rouge, or similar substances through a filter paper. Soap solutions, however, will wash these substances through filter papers. The greater the concentration of the soap up to certain definite limits for a given temperature, the greater will be the amount of the substance washed through.

Any of the alkalies mentioned, when added to the soap solution, will increase the amount of lamp black washed through by a certain quantity of soap solution. This property of the soap solution bears a very definite relation to another one of its properties that is called "surface tension." The surface tension of a liquid is that force which causes a volume of it to take the form that will have the least surface area, that is, a sphere. Liquids that have a high surface tension will form large drops when let fall from the end of a capillary tube and liquids

with a low surface tension will form small drops. In fact, the size of the drops formed under certain prescribed conditions affords a means of measuring accurately the surface tension. A new apparatus[1] has been devised for measuring surface tension which is said to make possible the most rapid method yet devised for making surface tension determinations.

Liquids of low surface tension will wet surfaces with which they come in contact more readily than will liquids of high surface tension. Soap-soda solutions have the lowest surface tensions of all liquids. Millard[2] has shown that soda ash, excluding caustic soda, is the most effective alkali for reducing the surface tension of soap solutions. All the known facts indicate that the detergent action of a soap-soda solution varies with its surface tension, in that the lower the surface tension the greater the detergent property of the solution. It seems, then, that soda ash is to be recommended as the most desirable alkali for laundry purposes.

Other reasons for the use of alkalies with soap are that some dirt on soiled linen contains acid substances, for the neutralization of which an alkali is required; that many greases contain free fatty acids and saponifiable fats that may be converted by the alkali into soap, thereby aiding in the detergent process; and that the presence of an alkali in a soap solution prevents to a certain extent the formation of lime soaps.

Effect of Alkalies on Textile Fibers.—Wool and silk fibers are injured by alkaline solutions (see Figure 8 in "The Conservation of Textiles"). If a fabric composed of a mixture of cotton, silk and wool fibers is boiled for 5 minutes in a 5% solution of caustic soda, the wool and

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[1]"Apparatus for Making Surface Tension Measurements," P. Lecomte Du Nuoy, *Journal of General Physiology*, May 20, 1919.

[2]"Surface Tension of Alkaline Soap Solutions," E. B. Millard, *Industrial and Engineering Chemistry*, Vol. 15, No. 8, p. 810.

silk will be dissolved from the cloth but the cotton will be left intact. Wool and silk are fibers of animal origin, while cotton is of vegetable origin. Fibers of animal origin should not be treated with alkalies except in special cases, as, for example, when the wash water is very hard or possibly when the fabric is extremely dirty. Dilute solutions of alkalies will not readily dissolve silk, although they have a pronounced yellowing action which varies in degree with the strength and the temperature of the solution. Alkalies react similarly towards wool and silk, rendering the fibers yellow in color and harsh to the feel. In concentrated solutions, they will completely destroy these fibers.

Cotton fibers are not affected appreciably by alkalies as ordinarily used in the laundry. It is true that alkalies have a slight yellowing effect on cotton fabrics. This yellowing effect is proportionate to the strength of the alkali that is used. The yellowing effect was studied in the laboratory by immersing samples of cotton cloth in solutions of caustic soda and soda ash, respectively, of 1% concentration on the basis of the water used, or the equivalent of about 4% concentration on the weight of the cloth treated. After the samples had been thoroughly saturated, they were removed from the solution and then dried, without rinsing or souring, for 5 minutes in an oven at 320°F. This treatment was repeated 5 times, the samples being soured between each successive treatment. The samples that were treated with the caustic solution showed more yellowing than those treated with the soda ash solution. However, when the samples were soured before being dried, they showed no yellowing effect. Although the concentrations of alkali used in this test were about 20 times the concentration of alkali that is ordinarily used in the wash-wheel, there is strong support given by the result of these tests to the practice

which is commonly followed of souring all classes of cotton or linen goods that are washed with soda and soap. Any traces of unneutralized soda that are left on the fabric at the end of the washing process have a tendency to yellow the fabric at the high temperature of the dryroom or ironing machine.

The samples that were given the treatment as outlined above without souring before drying were tested for breaking strength before and after the five successive treatments. The original breaking strength of a strip of the cloth one inch in width was 34.5 lbs. The samples that were treated with the caustic soda solution, also those treated with the soda ash solution, maintained their original strength after the five treatments. These tests then indicate that "souring" is to be recommended so that the development of a yellow color on the fabrics will be prevented. Futhermore, the tests show that the alkali left in the goods after a single treatment had not lowered the breaking strength of the samples after five successive treatments. The souring repeated, after each treatment, prevented the accumulation of alkali upon the fabric throughout the successive treatments, as would have happened had souring not been applied.

The work of Faragher[1] showed that when cotton threads are dipped into 1% solutions of soda ash and dried at 212°F. without souring, there was a loss of 15% in the breaking strength of the threads after ten successive treatments.

Action of Alkali on Cotton Thread in Contact with Air.—The work of Faragher further reveals that cotton threads when partly immersed in a 1% solution of soda ash and boiled for five hours did not show a loss in

[1]W. F. Faragher, *Journal of Industrial and Engineering Chemistry*, August, 1914, page 640.

breaking strength at that part of the thread that was at the surface of the solution and in contact, therefore, with both air and the solution. Faragher's work then proves that soda ash and weaker alkalies are certainly not unduly injurious to cotton fibers when in contact with alkaline solutions in the wash-wheel where air is constantly being mixed with the washing solution when the wheel is in motion.

Repeated tests have been made by the Department of Research upon cotton fabrics that have been washed as many as fifty times along with the regular work as it is handled in a power laundry using the standard L. N. A. formulas, which recommend the use of soap and soda ash. Some of the samples washed showed a loss of only 5% in breaking strength after fifty launderings, while other samples washed by the same process lost 15% in breaking strength. The structure of the fabric has considerable influence upon the manner in which it will withstand mechanical agitation in a wash-wheel and the losses in breaking strength of fabrics of dissimilar structure will, therefore, not always be identical.

It has been conclusively proved that when the washing is properly performed, fabrics suffer practically no deterioration due to the action of soap and soda ash.

Silicates as Washroom Detergents.—Silicates, usually sodium silicates, are being used extensively as "addition agents" in bar-soap for the domestic trade. The silicate imparts to the bar a hardness that enhances the appearance and also prevents a too rapid wasting away of the soap when being used. Whether or not sodium silicate is a good alkali for power laundry purposes must depend purely on its detergent properties. The discussion of the merits and demerits of silicates in this connection may be brought out in the answers to the following questions: Do silicates possess detergent properties in them-

selves, from a practical viewpoint? Do silicates improve the detergent properties of soap solutions? Are silicates injurious to cotton fabrics?

Stericker[1] has shown that sodium silicate of the composition $Na_2O.\ 3SiO_2$ has an emulsifying effect on saponifiable oils and that the silicate and soap are possibly better emulsifying agents, at certain concentrations, for mineral oils than soap and soda ash.

Millard[2] has shown that silicates have very little effect on the surface tension of soap solutions in comparison with soda ash. While it is true that surface tension is not necessarily a measurement of the detergent value of a solution, at the same time detergent values do seem to be pretty closely related to surface tensions.

Silicates are not necessarily injurious to cotton fabrics, although Herrmann[3] has reported that fabrics which were washed thirty times with silicates showed an ash content of 4.4%. The ash was mainly silicic acid. This high ash content caused by the accumulated deposition of silicic acid upon the fabric during repeated washings may eventually cause the fabric to acquire a harsh feel. This is a point to be settled by further research. It is a common practice in power laundries to apply powdered soap and sodas in the dry form to the wash-wheel. This is the most convenient way in which to use these supplies. At present there is no sodium silicate powder on the market that is readily and completely soluble in water. A powdered silicate would make a stronger appeal to the "laundry trade" than the ordinary silicate solution, although no conclusive evidence has been offered

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[1] *Journal of Industrial and Engineering Chemistry*, March, 1923.

[2] *Journal of Industrial and Engineering Chemistry*, August, 1923.

[3] *Mitteilungen aus dem Materialprüfungsamt*, 1921.

References: "Modern Theories of Detergent Action," T. Hedley Barry, *Chemical Age*, April 28, 1923, p. 446.

"Method of Determining the Detergent Action of Soaps," J. W. McBain, *J. Soc. Chem. Industry*, **42**, 373-8 T, 1923.

to indicate that silicates are superior to or even the equivalent of soda ash for general laundry purposes.

The Choice of an Alkali.—Experimentation along the line presented in the foregoing discussion has led to the conclusion that soda ash is, pound for pound, the most effective alkali of those commercially available, excepting caustic soda, which is to be recommended for use in special cases only. Potassium compounds are more expensive than sodium compounds. Excepting for minor special cases, their employment is not indicated by reason of economy or conservation of the life of goods undergoing laundering.

Bentonite as a Detergent.—Many claims have been made in favor of one form or another of the bentonite clays. An exhaustive study of this material has been made in the hope that it might prove to be of some value in the laundry washroom. A detergent for general purposes must be able to emulsify fats and oils and also to wet solids such as sand or coal dust. Both soap and alkalies individually or separately will emulsify oils or fats in water solution. But soap is required to quickly and thoroughly wet very finely divided coal dust. Bentonite and water will not act as an emulsifying agent for oils or fats nor will they readily wet finely divided coal dust. It might be supposed that thoroughly hydrated bentonite might adsorb oils or fats from a water "solution," but it does not do so to an extent warranting its use as a detergent for laundry purposes.

EXPERIMENTAL PART FOR STUDENT

1. Place 150 c.c. of distilled water in a bottle of small diameter, about two inches, and add one-half c.c. of cocoanut oil. Shake the bottle thoroughly and then set it aside for several minutes. Notice that the oil collects on the surface of the water. Pure water does not emulsify a vegetable oil or an animal fat.

2. To a second bottle containing 150 c.c. of water add two drops of cocoanut oil and ½ c.c. of a 5 per cent. solution of soda ash. Shake thoroughly. The oil now remains uniformly distributed throughout the water. An emulsion has been formed. A similar emulsion would be formed with any other vegetable oil or mineral fat, although the oil or fat must be in the liquid state, for the emulsification to take place.

3. Place 150 c.c. of hot (140° F.) distilled water in a bottle and add 2 drops of fatty acid, prepared by dissolving a small quantity of soap in hot water and precipitating the fatty acid with dilute sulfuric acid. The fatty acid will rise to the top of the solution. After adding two drops to the distilled water, shake the bottle and then set it aside for a few minutes. Notice the drops of fatty acid on the surface of the water. Now add one-half c.c. of the 5 per cent. soda ash solution. Shake the bottle again. Compare the appearance of the contents of this bottle with that of (2). When an oil or fat is finely divided so as to remain evenly distributed throughout the mixture, but is not sufficiently finely divided to form a clear solution, it is called an emulsion. In bottle (3) the soda ash has combined with the fatty acid to form a soap. The soap is completely soluble in water so that the solution is clear.

4. To a bottle containing 150 c.c. of water, add one-fourth gram of lamp-black. Shake the bottle thoroughly and then set it aside for a few minutes. Notice that the lamp-black comes to the surface of the water and that the water has not wet it. Now add one-half c.c. of the 5 per cent. soda ash solution to the bottle and shake it. Notice that the lamp-black still comes to the surface of the water and that none of it remains permanently suspended in the water.

5. Run an experiment similar to the above using machine oil instead of cocoanut oil, and kaolin (China-clay) instead of lamp-black.

Judging by the action of the soda ash on cocoanut oil, oleic acid and lamp-black in the preceding experiments, would you expect a soda to be a good washing agent for removing all these types of dirt from a fabric so that they may readily be rinsed out? When considering this question it must be remembered that unless the washing solution can either dissolve the dirt from the fabric or bring it into an emulsion or cause it to be suspended in the water, it falls short of fulfilling its function as a detergent.

QUESTIONS TO BE ANSWERED

1. Why is soda used with soap in the wash-wheel?

2. Which is the most satisfactory alkali to use from the standpoint of economy and safety?

3. Would soda be a good detergent for washing a fabric that is soiled only with coal dust or clay?

4. Why may butcher's aprons be washed with soda with the use of little or no soap.?

5. Should sodas be used in the suds-bath in the washing of wool or silk?

6. If traces of soda should be left on the fabric due to insufficient rinsing, how would the fabric be affected in the drying-room or on the ironing-machine?

7. What is the difference between a solution and an emulsion?

QUALITATIVE ANALYSIS OF ALKALIES

If the sample is of unknown composition, it is necessary to make qualitative tests for the following substances: free caustic soda or caustic potash, sodium carbonate, sodium bicarbonate, phosphates, borates and silicates. When caustic alkalies are present, bicarbonates are necessarily absent.

Silicates.—If it is thought that the sample contains less than 20 per cent. of silicate, dissolve about 2 grams of it in 100 c.c. of water. If the sample is not completely dissolved, the presence of earthy materials, such as clay or tripoli, may be suspected. Filter any insoluble matter from the solution and slowly acidify the filtrate with concentrated hydrochloric acid. Place the acidified solution in a porcelain dish and evaporate to dryness on a water-bath. After the sample is completely dry, treat it with 2 c.c. of concentrated hydrochloric acid and then 15 c.c. of water. Warm for a few minutes. If a precipitate remains, the presence of silicates is indicated.

Phosphates.—Dissolve about a 5 gram sample in 50 c.c. of water and acidify the solution with nitric acid. Place about 1 c.c. of ammonium molybdate solution (which must be neutral or slightly acid) in a test tube and add about ¼ c.c. of the sample in solution to the molybdate. A pale yellow precipitate indicates phosphates. For the full delicacy of the test to develop, the test-tube should be set aside for several hours if no precipate forms at once.

The reagent, ammonium molybdate, $(NH_4)_2MoO_4$, is prepared by dissolving molybdic acid, MoO_3 (100 grams), in ammonium hydroxide (250 c.c., sp.gr. 0.90, with 250 c.c. water), cooling, and slowly pouring this solution into well cooled fairly concentrated nitric acid (750 c.c., sp.gr. 1.42, in 750 c.c. water), with constant stirring.

Borates.—Treat half a gram of the sample to be tested with dilute hydrochloric acid to convert borates into boric acid. Evaporate to dryness. Treat the residue with 1 c.c. of warm wood alcohol (now called methanol) and burn the solution on a watch crystal or in an evaporating dish. A green flame indicates borates.

Corroborating Test.—A solution of a borate, acidulated with hydrochloric acid to a faintly acid reaction, imparts to a slip of turmeric paper wet with it a dark-red color, which on drying intensifies to a characteristic red color.

Hydroxides:—Caustic Soda and Caustic Potash.—When silicates are absent, but borates, phosphates or carbonates are present in the sample, proceed as follows:

To 10 c.c. of neutral alcohol add about 0.5 gram of the sample to be tested. If the alcohol is alkaline to phenolphthalein, caustic soda or caustic potash is present.

If silicates and borates are both absent from the sample, the test for hydroxide may be made by treating a solution of the sample with an excess of barium chloride to precipitate carbonates and phosphates. If the filtrate is alkaline to phenolphthalein, hydroxides are present.

Carbonates.—The presence of an appreciable amount of carbonate may be detected by the effervescence that results when a portion of the sample, dry or in concentrated solution, is treated with dilute mineral acid.

Bicarbonates in the presence of carbonates, other alkalies being absent.—Sodium bicarbonate cannot be present in a solution with caustic alkalies for the reason that bicarbonates are converted to carbonates by caustic alkalies.

To detect bicarbonate in the presence of carbonate, it is necessary to titrate equal portions of the sample to be tested with standard acid, using with the first phenolphthalein and with the second methyl orange, as indicators. If the methyl orange titration value is exactly double the phenolphthalein value, bicarbonates are absent. When the methyl orange titration exceeds twice the value of the phenolphthalein titration, bicarbonates are present. This test is based on the fact that bicarbonates are neutral to phenolphthalein but alkaline to methyl orange. Since by the titration of pure sodium carbonate with mineral acid, the carbonate is first converted to bicarbonate, phenolphthalein will indicate just half the titration value that would be obtained with methyl orange indicator. Therefore, when sodium carbonate and sodium bicarbonate are tested by titration with mineral acid, the methyl orange titration value will be greater than twice the phenolphthalein value.

QUANTITATIVE ANALYSIS OF ALKALIES

The following methods are applicable for the analysis of the hydroxides, carbonates and bicarbonates of sodium and potassium in the presence of each other, other alkalies being absent. Bicarbonates are not present if hydroxides are found.

Mixtures of carbonates and bicarbonates or of carbonates and hydroxides of the alkalies may be analyzed by a double titration with standard acid, using phenolphthalein and methyl orange, respectively, as indicators. If only sodium or potassium compounds are present, the amounts of carbonate and hydroxide can be calculated directly. The method of double titration is most valuable for mixtures of carbonate and hydroxide containing only a small proportion of carbonate. Where the percentage of carbonate is high, the barium chloride method should be used. Instead of using the barium chloride method, the sample may be titrated in neutral alcohol. Since carbonates are insoluble in alcohol and therefore not acted upon by the acid, it is possible to calculate the hydroxide present directly from the amount of standard acid used in the titration.

Moisture.—The moisture in carbonates may be determined by loss in weight of a sample, dried to constant weight at 105° C. For mixtures of carbonate and hydroxide or mixtures of carbonate and bicarbonate, the moisture is determined by difference after the sample has been titrated for alkali.

Since very little soda containing potassium compounds is used in the power laundry, these methods of analysis and the calculations are based on sodium compounds and the absence of potassium is assumed. If it is desired to make a quantitative determination of potassium in any particular soda, a standard method of analysis, such as the Lindo-Gladding method, should be consulted.

Sodium Carbonate and Bicarbonate.—Dissolve 5 grams of the sample in 200 c.c. of water and make up to 1 liter, using freshly boiled

distilled water. Titrate 200 c.c. of this solution—corresponding to 1 gram of the sample—with 0.5 N acid, using phenolphthalein as indicator, until the pink color just disappears. Add methyl orange and continue the titration until the solution again assumes a faint pink color. If the methyl orange titration is just double the phenolphthalein titration carbonates alone are present. If bicarbonates are present, twice the phenolphthalein titration will give carbonate, and the difference in the number of c.c. between the methyl orange titration and double the phenolphthalein titration will give bicarbonate.

Let x = c.c. standard acid used with phenolphthalein,
Let y = c.c. standard acid used with methyl orange;
y − 2x = c.c. standard acid required by bicarbonate.
2x = c.c. standard acid required by carbonate.
Calculation—1 c.c. 0.5 N acid = 0.02000 gram NaOH,
= 0.02650 gram Na_2CO_3,
= 0.01550 gram Na_2O.

The method just described yields approximate results for analyzing sesquicarbonate of soda or for neutral sodas that are mixtures of sodium carbonate with sodium bicarbonate.

Sodium Hydroxide.—Commercial caustic soda always contains a small amount of sodium carbonate. The carbonate and hydroxide can both be determined in one operation as follows: Dissolve 5 grams of the sample in 200 c.c. of water—freshly boiled—and make up to 1 liter. Take 200 c.c. of this solution, corresponding to 1 gram of sample, and dilute it to about 400 c.c. With phenolphthalein as indicator titrate with 0.5 N acid until the pink color just vanishes. Then add 4 drops of methyl orange and continue the titration until the pink color begins to reappear. The first titration gives the number of c.c. of acid required to neutralize all the hydroxide and half of the carbonate, since bicarbonate is neutral to phenolphthalein. The methyl orange titration gives the total alkalinity.

Calculation—Let x = c.c. standard acid used with phenolphthalein,
y = c.c. standard acid used with methyl orange;
then 2(y − x) = c.c. due to carbonate,
and y − 2(y − x) or 2x − y = c.c. of standard acid neutralized by hydroxide.

Quantitative Determination of Silica present as Alkaline Silicates.—Refer to X, under Standard Methods of Soap Analysis, Page 50, and apply the method there described for determining alkaline silicates in soaps, simply omitting the ignition of the sample. The sample containing soap is ignited in order to remove the organic matter of the soap.

Quantitative Determination of Phosphates.—Refer to XII, Standard Methods of Soap Analysis, Page 52, and proceed as with the residue left after removal of the soap by ignition or by solution in alcohol.

Quantitative Determination of Borax.—Select a sample of sufficient size to contain about 0.5 gram of borax. Refer to IX, Borax Determination—Standard Methods of Soap Analysis, page 50. Omit the fusion of the sample and proceed by dissolving it in water. Filter off any undissolved residue and add the filtrate to a 250 c.c. round bottom flask. Acidify with 1:1 hydrochloric acid, using methyl orange as indicator. Discard the solution.

Now select a fresh sample of the same size as the previous one, dissolve it and acidify as before, adding a slight excess of acid as determined by the previous titration. The methyl orange must be omitted in the latter acidification for it would interfere with the subsequent titration when phenolphthalein is the indicator.

Continue as under IX, Borax Determination, by adding a moderate excess of dry precipitated calcium carbonate.

Preferred Method for Analysis of Sesquicarbonate of Soda or for Mixtures of Sodium Carbonate with Sodium Bicarbonate.—Dissolve five grams of the sample in 200 c.c. of freshly boiled distilled water and make up the volume to one liter. Test a few cubic centimeters of this solution for the presence of hydroxide with a 10% solution of barium chloride, filtering off the precipitate, and adding a drop of 10% silver nitrate solution to the filtrate. A dark coloration denotes the presence of a hydroxide.

1. **Total Alkali.**—Take 200 c.c. of the solution, corresponding to one gram of the sample, for the titration. Add three drops of methyl orange and titrate quickly to the end point. Then take another 200 c.c. of the solution and quickly add about one c.c. less of 0.5 N acid than in the previous titration, taking care not to lose any of the solution by effervescence. Cover the beaker with a watch glass and boil to liberate free carbon dioxide. Cool the solution, add three drops of methyl orange and titrate to the exact end point. Add the standard acid a drop at a time and stir thoroughly between drops in order to get a sharp end point.

2. **Caustic Soda.**—If the sample contains caustic soda, take 200 c.c. of the solution, corresponding to one gram of the sample, add 100 c.c. of a 10% barium chloride solution and stir thoroughly. Filter off the precipitate and titrate the filtrate with 0.5 N acid, using phenolphthalein as indicator. Calculate caustic soda from the last titration.

NOTE.—When the sample contains hydroxide it will not contain bicarbonate. In such cases, subtract the titration required by the hydroxide from the titration for total alkali and calculate the difference to sodium carbonate.

3. **Bicarbonate.**—Take 200 c.c. of the solution, corresponding to one gram of the sample, and titrate with 0.5 N caustic soda solution until a drop of the solution gives a dark coloration immediately to a drop of a 10% silver nitrate solution on a spot plate. Calculate the titration to bicarbonate.

1 c.c. of 0.5 N caustic solution = 0.0420 gram of sodium bicarbonate.

NOTE.—Subtract the titration required by the bicarbonate from the titration for total alkali and calculate the difference to carbonate.

CHAPTER III

SOAPS

It would appear to be somewhat out of place to define the term "soap" in writing for laundryowners. It is, however, appropriate to state that, chemically, soap is a product formed by the reaction of any base, such as sodium, potassium, ammonium, calcium or lead hydroxide, with a fat. That is, "lead plaster" is, in a chemical sense, soap. But it is only those soaps formed with the first three mentioned bases that are soluble in water and that are, consequently, of interest in laundering. Even in normal times, we are almost entirely limited to the first one. It is well known that sodium soaps are hard and that potassium soaps are usually soft or pasty. Also, a potassium soap is a little more readily soluble in cold water than is a sodium soap made with the same fat. For this reason, potassium soaps are sometimes desirable for cold water washing. This property, however, may be had in a sodium soap by making it of a suitable fat. Ordinarily, the soaps properly made of the average stock, provided it is clean and free of unsaponifiable matter, are suitable for general power-laundry purposes. The majority of chipped soaps, as shown by the analyses made in this Department, are very good. Most chipped soaps are superior to the bar soaps generally supplied to the housewife.

Manufacturing Principles.—Every laundryowner is more or less familiar with soap-making, which is the simple saponification of glycerides or the neutralization of fatty acids by alkali. The methods employed today

by soap manufacturers are closely related to the original process that has been in use for centuries. Naturally, improvements have been made from time to time. New raw materials have been brought into use and a better product placed on the market; but in spite of all this, the chemistry of soap manufacture remains the same. The following reactions illustrate the chemistry involved:

$$\underset{\text{(Glyceride or ester of oleic acid)}}{(C_{17}H_{33}COO)_3.C_3H_5} + \underset{\text{(Caustic soda)}}{3\ NaOH} \rightarrow \underset{\text{(Sodium oleate or soap)}}{3C_{17}H_{33}COO.Na} + \underset{\text{(Glycerin)}}{C_3H_5(OH)_3};$$

$$\underset{\text{(Oleic acid)}}{C_{17}H_{33}\,COOH} + \underset{\text{(Caustic soda)}}{NaOH} \rightarrow \underset{\text{(Soap)}}{C_{17}H_{33}COO.Na} + \underset{\text{(Water)}}{H_2O.}$$

Saponification takes place in five stages or changes in a standard process of soap manufacture.

In the first change, a fat charge of from 25 to 40 tons of mixed oils and fats is run into the kettle. Many soap manufacturers prefer to run the charge into the kettle in two separate portions, the second portion being added after the second stage or change of saponification. This practice is favored because of the great increase in volume during the saponification process, due to the formation of steam filled bubbles. Once the lot is in the kettle, the steam is turned on and a weak caustic soda (20° Twaddle or 8.78%) is added until an emulsion is formed. Some oils are slow to emulsify; but once the emulsion is formed, the process proceeds smoothly, as a rule, caustic soda being added as fast as it is taken up by the fat.

Caustic soda of 40° to 57° Twaddle (17.67% to 25.8%) is then added to maintain the concentration. If the alkali is added too slowly, the mixture separates into large masses of soap enclosing free fat. As a preventive measure against this so-called "bunching," salt is thrown into the pan during the addition of alkali. When the mass no longer feels greasy and the lye which sep-

arates from the soap is free from turbidity on cooling, the first stage is considered as finished.

The second change is called "graining" and consists of adding the solid salt recovered from spent lyes or a saturated brine solution to the pan. This causes the soap to "grain" or to separate in closely packed particles. The spent lyes or water solution gradually settles out at the bottom of the kettle and is drawn off.

The third change consists of washing out any remaining glycerin. At this point, about one-half of one per cent. remains combined in the fat. The batch is boiled and open steam and water added to "close" the soap or bring it into a homogeneous solution. A "closed" soap has the smooth and transparent appearance of a stiff jelly. Salt is again added and "grained." After having settled, the spent lyes, containing most of the remaining glycerin and some of the coloring matter from the raw materials used, is pumped from the kettle. The washing and graining are repeated once more.

The fourth or strengthening change follows. The kettle is boiled as before with open steam and the soap "closed" by an addition of water. Small quantities of caustic soda (32°Tw. or 14.35%) are added in successive portions and the soap boiled with closed steam for at least two hours. The total alkali (calculated as Na_2O) added amounts to about 2% of the weight of the soap. As the alkali becomes sufficiently concentrated it "grains" out the soap in the same way as did the salt in the second change. The object of the strengthening change is to ensure complete saponification, as there may be as much as 20% unsaponified fat left at the end of the first change.

The object of the fifth change (called fitting) is to get the soap into a proper condition for the final slow settling, when the mass separates into soap and nigre.

Water is added to the "grained" soap, which is boiled with open steam, "closing" it as before. To arrive at the proper condition for settling, the proportion of soap and water must be carefully adjusted. Usually a close fit is desired, water being added in slight excess, and the soap being brought to the required condition by the addition of brine or strong lye. The soap is generally boiled for a short time with indirect steam heating and allowed to stand without a great fall in temperature, for a considerable period, sometimes for several days. In the final stage, four layers form:

1. A layer of foam, which is absent if the operations have been carefully carried out.
2. A good settled soap.
3. Nigre.
4. A small amount of spent lye.

The pure settled soap passes from the soap kettle to a crutcher, where it is agitated by rotating paddles for a short time. It is then run into large frames, holding 1,000 to 1,500 pounds of soap, and allowed to cool. The nigre, containing from 30 to 45% of fatty acids, is usually worked up into lower grades of soap.

Titer of Soap.—The term "titer" is universally recognized to indicate the temperature at which the fatty acids in soap solidify when the determination is made in accordance with the standard method for making the titer test.

Relation Between Titer and the Temperature at Which Soap Should be Used for Laundering Purposes.—Tallow is a compound of glycerin, and stearic, palmitic and oleic acids. The titer of these acids is as follows:

Stearic	69.3° C.
Palmitic	62.6° C.
Oleic	4.0° C.

It may readily be seen that a soap made from oleic acid alone would be of very low titer, while one made from

stearic acid would have a high titer. The soap made from tallow has a titer intermediate between the extremes. The so-called tallow laundry soaps that have been tested by this Department range in titer value from 38° C. to 44° C.

A soap made from stearic acid is not appreciably soluble in cold water and to make it at all valuable as a detergent a temperature close to the boiling-point of water is necessary.

Detergent Value of Soaps.—The theory of the detergent action of soap has been mentioned in Chapter II. Some facts brought out here are of interest in that they afford an accurate means of comparing the detergent values of different soaps. As far as present knowledge goes, however, there is no purely physical test that can be applied in grading commercial soap independently of a chemical analysis. This is true for the reason, pointed out in Chapter II, that added sodas increase the detergent powers of soaps and that it is not desirable to purchase sodas at soap prices. The test in conjunction with the usual analytical procedure is very valuable and it is hoped that it will come into more general use.

Use of Low Titer and High Titer Soaps.—A study was recently made of the surface tension of soap solutions at different temperatures with the following data as a result:

Surface tension of water in dynes per cm. at 25° C. 77
Surface tension of 0.05% sodium oleate in dynes per cm. at 25° C. . . .30
Surface tension of 0.05% sodium oleate in dynes per cm. at 60°C. 30
Surface tension of laundry soap, titer 42°, in dynes per cm. at 25° C. . .35
Surface tension of laundry soap, titer 42°, in dynes per cm. at 50° C. . .32
Surface tension of laundry soap, titer 42°, in dynes per cm. at 60° C. . .29
Surface tension of laundry soap, titer 42°, in dynes per cm. at 80° C. . .29

(Surface tension measurements were made with the Du Noüy surface-tension apparatus.)

Raising the temperature of the sodium oleate solution above 25° C. (77° F.) did not lower its surface tension, whereas the higher titer soap solution showed a lowering in surface tension as the temperature was raised.

Emulsifying Action of Low and High Titer Soap on Cocoanut Oil

No. 1	No. 2
100 c.c. distilled water	100 c.c. distilled water
1 c.c. 5% sodium oleate	1 c.c. 5% laundry soap, titer 42° C.
¼ c.c. cocoanut oil	¼ c.c. cocoanut oil

The two mixtures were shaken in cylindrical bottles of about 1½-inch diameter until the maximum lather was obtained.

No. 1 yielded at 23° C. a two-inch lather; at 50° C., a two-inch lather. No. 2 yielded at 23° C., a ¼-inch lather; at 50° C., a ½-inch lather.

The same type of test has been made with higher concentrations of cocoanut oil and with suspensions of clay or bone black. Raising the temperature of the higher titer soap mixture always produced a more abundant lather than was gotten at lower temperatures. The oleic acid soap mixture lathered as freely at room temperature as at 50° C.

Since for laundering as well as for toilet purposes soap is always applied until a free lather is obtained, it is important to know something about the relation between the surface tension, the titer, and the temperature at which certain soaps should be used. The foregoing data indicate that sodium oleate would do as good a job of washing at room temperature as at 50° C., but that a soap of titer 42° C. should be used not under 60° C. Practical washroom tests have demonstrated that the very low titer soap should be used at about 100° to 120° F., and the high titer one between 140° and 160° F.

The very low titer soap may be used at room temperature, but for an occasional encounter with a substance like paraffin; it must be placed in a bath hot enough to melt it before it can be washed from the fabric.

Purchase Specifications for Chipped Soap.—The term "neutral soap" is very widely used. The accepted meaning is that just enough sodium oxide is present in the soap to combine chemically with the fatty acids and no more. It means that there is in it no free caustic soda or other added alkaline material and that there is no excess of fatty acids. Some emphasis is placed on this explanation because in a chemical sense pure soap is not neutral but instead is an alkaline salt.

It is impracticable to market an absolutely pure soap. The allowable impurities are water, which should be present in a chipped soap in amounts around 10 to 12%, traces of common salt, sodium carbonate, and a few other minor impurities that are all incidental to the manufacturing process.

Of these impurities, it is obvious that water is a very important one. While a soap with 15% water may be of as good quality as one of 12%, it is not desirable to buy water at the price of soap. To a certain extent, the same thing is true of the sodas or so-called fillers, such as sodium carbonate, sodium silicate (water glass), trisodium phosphate, etc. While, as explained in the preceding chapter, these materials add to the detergent power of the soap, they are much cheaper than soap and should not be purchased at soap prices. It may be noted that alkaline fillers, notably a small amount of sodium silicate, function as preservatives in that they check the tendency of soaps made of certain fats to turn rancid. And, again, for some purposes they are objectionable, as, for instance, in washing silks and woolens. Even for general use, certain limited quanti-

ties only are needed. The presence of these added materials make it possible for a chipped soap to carry more water than a "neutral" soap and still appear dry.

Aside from the soluble fillers just mentioned, there are sometimes found in inferior grades of soap adulterants that contribute nothing but weight and are insoluble in water. Insoluble fillers should not be present in good soaps.

Rosin treated with caustic soda makes a soap similar in some properties to those made of fats. Rosin soap seems to have some considerable detergent power when mixed with soap made of fats and with plenty of alkaline filler. Rosin soap is, however, objectionable for several reasons and is moreover cheaper than soaps made with fats. In the large number of samples of chipped soaps examined in this Department, none has been found to contain appreciable amounts of rosin.

For a chipped soap, evidence so far gathered indicates that those in which the fatty acids are largely from tallow are the best for general laundry use.

The following is suggested as a safe purchase specification for chipped soap:

1. The soap should not have more than twelve per cent. of moisture.
2. It should have no free caustic alkali, certainly not over one-half of one per cent.
3. It should not have more than three per cent. of sodium carbonate.
4. It should not contain more than one per cent. of sodium silicate (water glass).
5. It should have no insoluble filler.
6. The sum of the sodium oxide as soap and anhydrous fatty acids should not be less than eighty-five per cent.
7. The fatty acids should contain no rosin.

Sampling of Chip Soap.—Since the water content of a soap is an important factor in its evaluation, the sample should be carefully taken so as to truly represent the moisture content of the shipment and should be placed immediately in a glass container that can be

sealed air-tight. It is, for this reason, practically useless to analyze a sample of soap that has been shipped in a paper or wooden container. The best procedure is to weigh the barrel of soap, to learn whether the weight as received agrees with the billed weight. Then open the barrel and remove several scoops until a sample of about one-half pound may be taken from near the center of at least several of the containers. The various sample portions should be thoroughly mixed and about a pound of the mixture placed in a fruit jar, so that it may be tightly sealed and sent to the laboratory for analysis.

Importance of Accurate Sampling and Moisture Determination in Soap Purchase.—To buy water at the price of soap is wasteful, as anyone will admit. If a manufacturer is selling soap on a 12% moisture basis, it is very likely that at least this amount will be present when the billing weight is taken. If the weather is dry, or, if in the winter time, the soap is stored in a warm room, some of this moisture is going to evaporate and there will result a shrinkage in weight. Suppose, for instance, that a laundryowner purchased 600 pounds net of soap on a 12% moisture basis. That would mean that he is to receive 528 pounds of pure dry soap at his plant, plus whatever quantity of moisture the material carries. Suppose that when the shipment is weighed in at the plant the net weight is 574 pounds. There is an apparent shortage of 26 pounds. A sample of the soap should then be taken and at least a moisture determination made. Suppose the moisture content is found to be 8%. Then for every hundred pounds of material weighed in, he is receiving 92 pounds of dry soap, or $92 \times 5.74 = 528$ pounds, or exactly what his purchasing contract called for. If, on the other hand, the soap weighed in 625 pounds net weight, one is not to assume that he is getting

any more than he has paid for, until the moisture determination and the calculations have been made. Assuming that the moisture determination showed 15.5%, the amount of dry soap would be 528 pounds, or the same as 600 pounds of soap with 12% moisture. The important thing to be determined for the protection of the purchaser is that the amount of soap with the moisture as received is equivalent to the amount of soap contained in the weight billed with the moisture content as specified in the purchase contract, which is usually 12%. An easy way to calculate this is to multiply the billed weight by 88 and divide the result by 100. This will give the weight of moisture-free soap purchased. Then determine the net weight of soap received and the moisture content by having a carefully taken sample analyzed, or by making the moisture determination as described in the following paragraph. Subtract from one hundred the percentage of moisture found, multiply this number by the weight of soap as received, and divide the result by one hundred, which gives the amount of moisture-free soap received. Obviously, this should be the same amount as that obtained above for the weight of moisture-free soap purchased.

To Make Moisture Determination of Soap in the Plant.—It is well to note here that a very close estimate of the moisture content of soap may be made in the laundry. Weigh out on scales about five to ten pounds of soap from the center of a freshly opened barrel, and place the soap, spread out on a tray, in the dry room and leave it for several hours. Then let the soap cool to room temperature and at once weigh again. The first weight minus the last weight divided by the first weight and multiplied by 100 is the percentage of moisture. Exam-

ple: Weigh out 10 pounds of chipped soap. After drying, it weighs 8 pounds and 8 ounces, or 8½ pounds. Then, $100[(10-8\frac{1}{2})\div 10]=15\%$. The precautions regarding sampling of soap for analysis apply to all kinds of soap.

Powdered Soap and Soap Powders.—The growth of the popularity of the use of dry soap to replace soap solutions has brought upon the market a number of brands of powdered soap of very excellent quality. By the term "powdered soap" is meant a soap in the powdered form that contains no appreciable proportion of filler, the only impurity being a small percentage of moisture. These powdered soaps usually contain much less moisture than the flaked soaps.

The term "soap powder" has been reserved for the soap product sold in powdered form, which usually carries from 16 to 40 per cent. of some compound of soda and a higher percentage of moisture than is contained in the "neutral" chipped soaps. Of these products, some have been found to be very good and others have been found to be very inferior. The advice of this Department should always be sought regarding any products of this character that are under consideration for purchase. This higher moisture content is made possible by the nature of the soda, as mentioned earlier in this chapter. Sodium carbonate can absorb its equal weight of moisture and yet appear in a dry, powdered form. One hundred sixty-four parts of anhydrous trisodium phosphate will absorb 216 parts of moisture and yet appear dry. That is, the moisture enters into the crystalline structure of the solid. Thus it is that soap powders often contain more water than neutral soap and yet appear to be dry.

Also, the presence of a large proportion of alkaline filler will permit of the use of inferior soap stock without

betraying the fact by the odor of the soap. On the other hand, the large amount of filler makes possible the use of some low-melting fats, which are desirable on account of their greater solubility in cold water.

The important things to consider, therefore, in purchasing soap powders are the percentage and the quality of real soap, it being an obviously poor bargain to purchase soda and water at soap prices. There are a few very good soap powders on the market and a much larger number of inferior ones.

Soap Pastes.—There are occasionally offered proprietary preparations for cleaning French cuffs. Some of these contain a small percentage of organic solvents, such as carbon tetrachloride, chloroform or ether. Experiments in this Department, and the evidence to be found in the work of others, indicate that these solvents, in the quantities usually found and under the conditions generally used, are of very doubtful advantage. Moreover, the price is seldom equitable because of the large proportion of water in the material. A representative one of these soap pastes gives the following analytical results:

Water	71.4%
Dry soap	21.5%
Water glass	1.4%
Sodium carbonate	3.4%
Common salt	2.3%

For cleaning French cuffs with a brush, there appears to be some advantage in having a thick soap paste, but this material can be readily made in the laundry by boiling 20 pounds of soap in 60 gallons of water. In order to obtain a grainy structure, stir rapidly while cooling. A small amount of soda may be added if desired; but since many of the French cuffs contain silk or rayon fibers, it is best to omit the soda. These materials have

been thoroughly tested out in the laboratory and samples of the proprietary pastes and those made up in the laboratory have been compared in various laundries under marks of identification unknown to the user. No difference could be distinguished.

In fact, the experience of this Department and the best knowledge on the subject indicate that one soap and one soda are the only detergents necessary for any laundry.

EXPERIMENTAL PART FOR STUDENT

1. Preparation of a tallow soap.

Dissolve 1.4 grams of caustic soda (76% Na_2O), in 50 c.c of water. To the hot solution in a casserole add 10 grams of tallow. Heat this mixture for about 10 hours on the water-bath, occasionally making up the water that is lost by evaporation. What has happened to the tallow?

(a) Is there any free alkali in the soap?

(b) Is there any unsaponified tallow?

To test for free alkali, dissolve about ½ gram of the soap paste in fifteen c.c. of neutral alcohol and then add a few drops of phenolphthalein. If the solution turns pink, the soap contains free alkali. In case the soap is strongly alkaline, stir into the paste sufficient oleic acid, ¼ c.c. at a time, until the free alkali has been completely neutralized as indicated by the phenolphthalein test.

The test for unsaponified fat will detect as little as one per cent. of unsaponified material. Dissolve about ½ gram of the sample in 10 c.c. of ethyl alcohol. The solution should be clear. Then add 10 c.c. of concentrated ammonia water to the alcohol solution. If an appreciable amount of unsaponified fat is present, the solution will become turbid.

2. Preparation of a "red oil" soap.

To 25 c.c. of water, add 5 c.c. of oleic acid (red oil). Then dissolve one gram of caustic soda in 5 c.c. of water and stir the caustic solution into the water-oleic acid mixture. What has happened? Does the product contain any free alkali? What is the difference between a fatty acid and a glyceride?

3. With part of the soap prepared in (2) repeat the experiments as outlined under Chapter II, using a soap solution instead of the five per cent. soda ash solution. Notice particularly the difference in the action of soap and soda solution on bone black.

4. Soda as a "soap builder."

To 100 c.c. of distilled (soft) water add 5 c.c. of cocoanut oil and then sufficient of a 5 per cent. neutral soap solution with intermittent shaking to form a permanent suds. About 3.5 c.c. of the soap solution will be required.

To another bottle, containing the same amount of water and cocoanut oil, add 1.5 c.c. of a 5 per cent. soda ash solution. Then with intermittent shaking add sufficient of the 5 per cent. soap solution to form a permanent suds. It will be found that only about half as much soap will be required to form a suds with this amount of soda present as was required without the soda.

Why use soda in connection with soap for washing cotton and linen fabrics?

5. Repeat (4) using hard water instead of distilled water.

QUESTIONS TO BE ANSWERED

1. What is a glyceride and how may soap be made from it?
2. What is a fatty acid and how may it be converted into soap?
3. Define titer.

4. Define surface tension.
5. Which has the higher surface tension, pure water or a solution of soap in water?
6. What is the effect of hard water on a soap solution? Demonstrate.

STANDARD METHODS FOR SOAP ANALYSIS

A complete chemical analysis of a soap sample is not easily made unless the analyst is trained in this line of work. Even among experts there has been some difference of opinion as to the procedure to be followed in order to obtain accurate analytical data.

In order that all those interested in the analysis of soaps may use the same methods, the Committee on Methods of Analysis and Specifications of Commercial Soaps and Soap Products of the Division of Industrial Chemists and Chemical Engineers of the American Chemical Society has agreed unanimously on the following as Standard Methods for the Analysis of Commercial Soaps and Soap Products. The sample to be analyzed must be selected according to directions on page 39.

Methods of Analysis. When a determination shows nonconformity with the specifications, a duplicate shall be run.

I. Matter Volatile at 105° C.—Weigh 5 g. of the sample in a porcelain or glass dish about 6 to 7 cm. in diameter and 4 cm. deep, dry to constant weight in an inert atmosphere at a temperature not exceeding 105° C.

II. Total Matter Insoluble in Alcohol. Free Alkali or Free Acid—(1) *Matter insoluble in alcohol.* Digest hot a 10-g. sample with 200 c.c. of freshly boiled ethyl alcohol neutral to phenolphthalein (94 per cent. or higher). Filter through a counterpoised filter paper neutral to phenolphthalein, or a weighed Gooch crucible with suction, protecting the solution during the operation from carbon dioxide and other acid fumes. Wash the residue on the paper, or in the crucible, with hot neutral alcohol until free from soap. Dry the filter paper, or crucible, and residue at 100° to 105° C. for 3 hrs., cool, and weigh the total matter insoluble in alcohol.[1]

(2) *Free alkali or free acid.* Titrate the filtrate from the above, using phenolphthalein as indicator, with standard acid or alkali solution, and calculate the alkalinity to sodium hydroxide (or potassium hydroxide), or acidity to oleic acid.

(3) *Matter insoluble in water.* Proceed as in the determination of matter insoluble in alcohol. After filtering and thoroughly washing the residue, extract it with water at 60° C., and wash the filter thoroughly. (When the matter insoluble in water is all inorganic, boiling water may be used for the extraction and washing.) Dry the filter

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[1]The matter insoluble in alcohol will contain most of the alkaline salts, such as carbonates, borates, silicates, phosphates and sulfates, as well as starch, and may be used for the approximate determination of these constituents. These salts are not entirely insoluble in alcohol, so for accurate determinations separate portions of the soap should be used.

For determination of carbonates see XI; phosphates, XII; sulfates, XIII; silicates, X; borax, IX; starch, XIV(4).

and residue at 100° to 105° C. for 3 hrs., cool, and weigh matter insoluble in water. The nature of this matter may be determined by further examination.

(4) *Total alkalinity of matter insoluble in alcohol.* (*Alkaline salts.*) Titrate the filtrate from the determination of matter insoluble in water with standard acid, using methyl orange as indicator. Calculate the alkalinity to sodium oxide (Na_2O), and, if desired, to any other basis agreed upon by the parties interested.

III. Combined Alkali. Total Anhydrous Soap.—Dissolve 5 to 10 g. of the sample, depending upon the anhydrous soap content, in 100 c.c. of water in a 250-c.c. Erlenmeyer flask. When solution is complete, add dilute sulfuric acid in slight excess, insert a small funnel in the neck of the flask, and heat the flask at a temperature not exceeding 60° C. until the fatty acids separate as a clear layer. Transfer to a separatory funnel, draw off the acid layer into a second separatory funnel and shake the acid aqueous liquid with two 20-c.c. portions of ethyl ether. Dissolve the fatty acids in the ether used for washing the aqueous liquid and shake with 10-c.c. portions of water until they are no longer acid to methyl orange. Unite the water portions used for washing and shake with 20 c.c. of ether. Wash this ether until the wash water is neutral to methyl orange. Save the acid water for chloride determination. Unite the ether solutions (if necessary, filter, washing the paper with ether) in a suitable weighed vessel, add 100 c.c. of neutral alcohol free from carbon dioxide, add phenolphthalein and titrate to exact neutrality with standard sodium hydroxide solution. Evaporate off the alcohol, dry to constant weight as in the determination of matter volatile at 105° C. and calculate the percentage of soda soap. This soap naturally includes any mineral oil and neutral fat, which, if determined separately, must be deducted from the result to obtain the true soap. Calculate the combined sodium oxide (Na_2O) and deduct from the weight of soda soap to give the anhydrides. If the original soap was potash soap, proper calculation must be made to reduce to potassium oxide (K_2O), or the titration made directly with standard potassium hydroxide solution. In case the soap shows an excess of free acid, proper corrections must be made in calculating the combined alkali in the original soap.[1] (See determination of rosin.) With soaps containing a large amount of soluble silicates and soap products containing a high percentage of finely divided material insoluble in water, the foregoing procedure cannot be applied as given. In such cases the filtrate obtained in the determination of total matter insoluble in alcohol can be used after neutralizing any free acid or alkali. Evaporate off the alcohol on a steam-bath, take up in water and proceed as above.

With soap products containing a high percentage of matter insoluble in alcohol where approximate results will suffice, such as may be the case with cleansers, soap powders, scouring compounds, pastes, etc., and where agreed upon by the parties interested, the alcoholic solution, obtained after filtering off and washing the matter insoluble in alcohol, may be evaporated directly in a weighed vessel, dried at 105° C. to constant weight, and the result reported as soap.

IV. Chloride.—Neutralize with chlorine-free alkali the acid water obtained in paragraph III. Titrate with standard silver nitrate solu-

[1] A blank test should be made on the sodium or potassium hydroxide solution for neutral salts and the proper corrections made if necessary.

tion, using potassium chromate as indicator, and calculate the result to sodium chloride or potassium chloride as the character of the soap indicates.

In case the total anhydrous soap is not to be determined, it will be more convenient to use the following method:[1] Dissolve 5 g. of the sample in 300 c.c. of water, boiling if necessary to effect solution. Add an excess of neutral, chlorine-free magnesium nitrate solution (about 25 c.c. of a 20 per cent. $Mg(NO_3)_2.6H_2O$ solution). Without cooling or filtering, titrate with standard silver nitrate solution, using potassium chromate as indicator.

V. Unsaponified and Unsaponifiable Matter.—Weigh 5 g. of the soap into a beaker and dissolve in about 100 c.c. of 50 per cent. alcohol on the steam bath. If the sample has been found to contain free fatty acid, add just enough aqueous alkali to neutralize this. Evaporate off the bulk of the alcohol, take up with about 200 c.c. of hot water and transfer to a separatory funnel of about 500-c.c. capacity, designated as No. 1. When cool, rinse out the beaker with about 50 c.c. of ether and add it to the soap solution. Shake thoroughly for one minute. By the addition of small amounts of alcohol (5-c.c. portions and the total not to exceed 25 c.c.), a clear and rapid separation of the aqueous and ether layers is effected. After adding each alcohol portion, the separatory funnel is not shaken but merely given a whirling movement. Draw off the aqueous portion into another separatory funnel, designated as No. 2. Wash the ether solution with 10-c.c. portions of water until this water is no longer alkaline to phenolphthalein. Add all these washing to funnel No. 2 and extract this solution with 20-c.c. portions of ether until the ether is absolutely colorless (3 or 4 extractions should be sufficient). Combine these ether extracts in a third separatory funnel (No. 3) and wash with 10-c.c. portions of water until the water is no longer alkaline to phenolphthalein. Now add the ether in funnel 3 to that in funnel 1, a small amount of ether being used to rinse out funnel 3. Wash the ether solution with 20 c.c. of 10 per cent. hydrochloric acid solution and then successively with 20-c.c. portions of water until the water is no longer acid to methyl orange. Filter the ether solution through a dry filter paper into a weighed beaker or flask. Evaporate or distil off the ether on the steam-bath, dry as under the determination of matter volatile at 105° C. and weigh the residue, then heat with alcohol and, when cool, neutralize with standard alkali, using phenolphthalein. Deduct any appreciable amount of fatty acid found by this titration from the weight of the residue. This residue consists of the unsaponifiable matter and any neutral fat that may have been present in the soap. In case it is desired to separate these, thoroughly saponify the residue with alcoholic alkali and repeat the foregoing procedure. The residue obtained is unsaponifiable matter only.

VI. Rosin.—*Wolff's method.*[2] Dissolve 5 g. of the sample in 100 to 200 c.c. of hot water, add a slight excess of dilute sulfuric acid, heat until the fatty acids collect in a clear layer, cool to room temperature, extract with a small portion of ether, draw off the water layer and wash the ether solution with water until free from mineral acid. Transfer to a 200-c.c. Erlenmeyer flask, evaporate off the ether and dry 1 hr.

[1] H. C. Bennett, *Journal of Industrial and Engineering Chemistry*, **13** (1921), 813.
[2] *Chemiker-Zeitung*, **38** (1917), 369, 382, 430; *Chemical Abstracts*, **8** (1914), 2495.

at 105° C., cool and dissolve in 20 c.c. of absolute alcohol. Then add 10 c.c. of a solution of one volume of concentrated sulfuric acid (sp. gr., 1.84) and 4 volumes of absolute alcohol, and boil on the steam-bath for 4 min. under a reflux condenser. Remove from steam-bath, add to the liquid about 5 times its volume of 7 to 10 per cent. sodium chloride solution, and extract with ether. Shake out the aqueous portion 2 or 3 times with ether. Unite the ether solutions and wash with sodium chloride solution until the washings are neutral to methyl orange. Add 30 c.c. of neutral alcohol, and titrate the rosin acids with standard sodium hydroxide solution, using phenolphthalein as indicator. Calculate to rosin or rosin soap, as desired (1 c.c. normal alkali = 0.346 g. rosin or 0.377 g. rosin soda soap). If the true fatty acid soap is desired, subtract the rosin soap from the total anhydrous soap obtained under III.

VII. Titer Test.—(1) *Preparation of total fatty matter (fatty and rosin acids and unsaponified matter).* Dissolve about 50 g. of soap in 500 c.c. of hot water, add 100 c.c. of 30 per cent. sulfuric acid, heat until the fatty matter collects in a clear layer, siphon off the acid layer and wash the fatty matter free from sulfuric acid with hot water. Decant the fatty matter into a dry beaker, filter, using a hot-water funnel, or placing both funnel and receiving beaker in a water-jacketed oven, and dry for 20 min. at the temperature of boiling water.

When other determinations are to be made on the total fatty matter, and volatile and readily oxidizable fatty acids are present, the following method should be used: Dissolve about 50 g. of the soap in 300 c.c. of hot water, transfer to a separatory funnel, add 150 c.c. of approximately 2*N* sulfuric acid, cool somewhat, add 120 c.c. of ether, shake, draw off the acid layer, and wash the ether layer free from acid with a strong salt (NaCl) solution. Then draw off the aqueous layer as completely as possible, transfer the ether layer to a flask (it is not necessary to transfer quantitatively), add 20 to 30 g. of anhydrous sodium sulfate, stopper the flask, shake, and let stand at a temperature below 25° C. until the ethereal liquid becomes perfectly clear, showing that all water has been taken up by the sodium sulfate. Filter through a dry paper into another Erlenmeyer flask, and completely evaporate off the ether by passing through the flask a current of dry air and heating the flask to a temperature not above 50° C.

(2) *Determination.*[1] (*a*) *Thermometer.* The thermometer shall be a standard titer thermometer graduated at zero and in tenth degrees from 10° to 65° C., and certified by the U. S. Bureau of Standards.

(*b*) *Procedure.* Transfer the fatty acids prepared as under VII(1), when cooled somewhat, to a titer tube 25 mm. by 100 mm. placed in a 16-oz. salt-mouth bottle of clear glass 70 mm. by 150 mm., fitted with a cork that is perforated so as to hold the tube rigidly when in position. Suspend the titer thermometer so that it can be used as a stirrer and stir the fatty acids slowly (about 100 r. p. m.) until the mercury remains stationary for 30 sec. Allow the thermometer to hang quietly with the bulb in the center of the tube and report the highest point to which the mercury rises as the titer of the fatty acids. The titer should be made in a room at about 20° C. for all fats having a titer above 30° C. and at 10° C. below the titer for all other fats.

[1] "Methods of Analysis of Association of Official Agricultural Chemists," **1920**, 242. Fat Analysis Committee Method, *Journal of Industrial and Engineering Chemistry*, **11** (1919), 1163.

VIII. Acid Number of Fatty Acids.—(1) *Preparation of fatty acids.* Follow procedure given under VII.

(2) *Determination.* In a 250-c.c. Erlenmeyer flask dissolve 2 g. of the fatty acids, accurately weighed, in 20 to 30 c.c. of neutral 95 per cent. ethyl alcohol. Titrate with standard alkali, using phenolphthalein as indicator. Calculate the acid number (mg. of KOH per g. of fatty acids).

IX. Borax Determination.[1]—Weigh 10 g. of the soap (or 5 g. if more than 5 per cent. of borax is present) into a platinum dish and add 2.15 g. of fusion mixture (consisting of 200 g. sodium carbonate and 15 g. silica in fine powder). To this mixture add 15 c.c. of alcohol, mix with the aid of a glass rod and, after washing the rod with a little alcohol, evaporate the mass to dryness on the water bath. Ignite until the combustible material is destroyed, cover the dish with a piece of platinum foil and fuse. Completely disintegrate the fusion by boiling with water and transfer the solution to a 250-c.c. round-bottom flask. Acidify with 20 c.c. of dilute hydrochloric acid (1:1), heat nearly to boiling, and add a moderate excess of dry precipitated calcium carbonate. Connect with a reflux condenser and boil vigorously for 10 min. Filter out the precipitate through a folded filter, washing several times with hot water, but keeping the total volume of liquid below 100 c.c.

Return the filtrate to the flask, add a pinch of calcium carbonate and again boil under a reflux condenser. Remove the flame and connect the top of the condenser with a water pump. Apply the suction until the boiling has nearly ceased. Cool to ordinary temperature, add 50 c.c. of neutral glycerin and titrate the solution with 0.1*N* sodium hydroxide, free from carbonate, using phenolphthalein as indicator. After the end-point is reached add 10 c.c. more of glycerin and again titrate. Repeat this process until the addition of glycerin causes no further action on the end-point. The number of cubic centimeters required multiplied by 0.00955 will give the equivalent of borax ($Na_2B_4O_7.10H_2O$) present in the solution.

X. Determination of Silica Present as Alkaline Silicates.—When the material contains no mineral matter that is insoluble in water, ignite a sample of the soap containing not to exceed 0.2 g. of silica in a platinum dish at a low temperature. When charred, extract the soluble salts with water, return the paper and charred residue to the dish and complete the ignition. Unite the residue in the dish and the water extract, carefully acidify with hydrochloric acid, finally adding the equivalent of from 5 to 10 c.c. strong hydrochloric acid in excess. The dish or casserole containing the solution should be covered with a watch glass while adding acid so as to avoid loss by spray.

When the material contains mineral matter insoluble in water, or a determination of highest accuracy is not necessary, take a portion of the solution after titrating the matter insoluble in alcohol II(4) containing not more than 0.2 g. silica and add 5 to 10 c.c. strong hydrochloric acid.

Evaporate the acidified solution (washing off and removing the cover glass if used) to dryness on steam-bath or hot plate at a temperature not exceeding 200° C. Cool, moisten with concentrated hydrochloric acid, let stand 5 to 10 min., breaking up all lumps with

[1]Poetschke, *Journal of Industrial and Engineering Chemistry*, **5** (1913), 645.

a stirring rod. Add about 25 c.c. of hot water. Heat a few minutes and filter through a small ashless paper. Wash thoroughly with hot water.

Evaporate the filtrate to dryness and repeat the above treatment, filtering on a second paper. Carefully ignite the two papers and contents in a weighed platinum crucible, first at a low temperature until the paper is consumed, but finally heating to constant weight over the blast lamp; cool in a desiccator before weighing. If extreme accuracy is desired, moisten the contents of the crucible with water; add 10 c.c. of hydrofluoric acid and 4 drops of strong sulfuric acid, evaporate to dryness over a low flame, ignite at the temperature of the blast lamp for about 2 min., cool in a desiccator and weigh. The difference between this weight and the previous weight is the weight of the silica (SiO_2). [1]

To calculate sodium silicate ($Na_2Si_4O_9$), multiply weight of SiO_2 by 1.26.

XI. Determination of Carbon Dioxide (Carbonates).—For most determinations the dry matter insoluble in alcohol as obtained in II (1) will be suitable for this determination. In some cases it might be desired to run the test directly on an original sample of the soap. This should always be done when the highest accuracy is required. Any reliable absorption method for determining carbon dioxide may be used.[2]

The following is a method which has proved satisfactory:

A 250-c.c. Erlenmeyer flask is placed on a gauze over a burner. The flask is equipped with a 2-hole rubber stopper, through one opening of which is a 10-in. reflux condenser and through the other a thistle tube equipped at the outer end with a 3-way stopcock. The lower end of the thistle tube is drawn to a small point, which is placed very close to the bottom of the flask. To the straightaway end of the stopcock is attached a small funnel for the introduction of acid to the flask. The other opening of the stopcock is attached to receive air from a purifying train consisting of a wash bottle containing concentrated sulfuric acid and a second at the outer end of the train containing a 50 per cent. solution of potassium hydroxide. The top of the reflux condenser is attached first to a drying wash bottle containing concentrated sulfuric acid, and then to a weighed absorbing train consisting of a suitable potash bulb charged with 50 per cent. potassium hydroxide, and a second containing concentrated sulfuric acid. This train is attached to a protective U-tube containing calcium chloride. The U-tube is attached to an aspirator.

Procedure. Set up the apparatus, leaving out the weighed train, and aspirate with a slow stream of the dry carbon-dioxide-free air until the apparatus is freed from carbon dioxide. Insert the train and continue the aspiration for ½ hr. Check the weight of the train to determine if the air is passing through too fast, or if the system is free from carbon dioxide. The system must be free from leaks. Weigh out 1 or 2 g. of the sample into the Erlenmeyer flask, cover with 20 c.c. of freshly boiled distilled water, close the apparatus with the train in

[1] "The Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand, *U. S. Geological Survey Bulletin* **700**, 102.

[2] "Methods of Analysis of Association of Official Agricultural Chemists," **1920**, 277; *Bureau of Chemistry Bulletin* 107, 169.

place. Add 20 c.c. of dilute hydrochloric acid (1:1) through the funnel very slowly, with no heat being applied to the flask. The rate of adding acid should be carefully controlled so that the gas does not pass through the train too rapidly. As soon as the acid is added, start aspiration gently. When the absorption begins to stop the gas flow, start heating gently and continue until the contents of the flask have boiled 15 to 20 min. Stop heating and continue aspirating until the flask has cooled down. Remove the train and weigh. Calculate increase of weight as carbon dioxide. Carbon dioxide multiplied by 2.41 equals sodium carbonate.

XII. Determination of Phosphates.[1]—If a qualitative test has shown the presence of phosphates and their determination is desired, the matter insoluble in alcohol II(1) or the ash from the incineration of an original sample can be used. An original sample should always be used when the highest accuracy is desired.

(1) *Reagents.* (*a*) *Molybdate solution.* Dissolve 100 g. of molybdic acid in dilute ammonium hydroxide [144 c.c. of ammonium hydroxide (sp. gr. 0.90) and 271 c.c. of water]; pour this solution slowly and with constant stirring into dilute nitric acid [489 c.c. of nitric acid (sp. gr. 1.42) and 1148 c.c. of water]. Keep the mixture in a warm place for several days or until a portion heated to 40° C. deposits no yellow precipitate of ammonium phosphomolybdate. Decant the solution from any sediment and preserve in glass-stoppered vessels.

(*b*) *Ammonium nitrate solution.* Dissolve 200 g. of commercial ammonium nitrate, phosphate-free, in water, and dilute to 2 liters.

(*c*) *Magnesia mixture.* Dissolve 110 g. of crystallized magnesium chloride ($MgCl_2.6H_2O$) in water, add 280 g. of ammonium chloride, 261 c.c. of ammonium hydroxide (sp. gr. 0.90), and dilute to 2 liters.

(*d*) *Dilute ammonium hydroxide for washing.* Dilute 100 c.c. of ammonium hydroxide (sp. gr., 0.90) to 1 liter.

(2) *Determination.* Weigh out a 2-g. sample of the alcohol-insoluble or ash, and proceed as in X for removal of silica, saving the filtrate. Make up to 250 c.c., concentrating if necessary. Take an aliquot corresponding to 0.50 g. or 1 g., neutralize with ammonium hydroxide, and clear with a few drops of nitric acid. Add about 15 g. of dry ammonium nitrate or a solution containing that amount. To the hot solution add 70 c.c. of the molybdate solution for every decigram of phosphoric acid (P_2O_5) present. Digest at about 65° C. for an hour, and determine if the phosphoric acid has been completely precipitated by the addition of more molybdate solution to the clear supernatant liquid. Filter and wash with cold water or, preferably, ammonium nitrate solution. Dissolve the precipitate on the filter with ammonium hydroxide and hot water, and wash into a beaker to a bulk of not more than 100 c.c. Nearly neutralize with hydrochloric acid, cool, and from a buret add slowly (about 1 drop per sec.), stirring vigorously, 15 c.c. of magnesia mixture for each decigram of phosphoric acid (P_2O_5) present. After 15 min. add 12 c.c. of ammonium hydroxide (sp. gr. 0.90). Let stand till the supernatant liquid is clear (2 hrs. is usually enough), filter, wash with the dilute ammonium hydroxide until the washings are nearly free from chlorides, ignite to whiteness or to a grayish white, weigh, and calculate to phosphoric acid (P_2O_5), or alkaline phosphate known to be present.

[1] "Methods of Analysis of Association of Official Agricultural Chemists," **1920**, 1.

XIII. Determination of Sulfates.—For most determinations the matter insoluble in alcohol obtained under II may suffice. If a determination of the highest accuracy is desired, ignite a 10-g. sample of the soap and use the ash from the ignition. Digest with 100 c.c. of water, cover with a watch glass, and neutralize carefully with hydrochloric acid. When neutralized, add 5 c.c. excess of hydrochloric acid, filter, and wash the residue thoroughly.[13] Make up the filtrate to 250 c.c. in a beaker, and boil. To the boiling solution add 15 to 20 c.c. of 10 per cent. barium chloride solution slowly drop by drop from a pipet. Continue boiling until the precipitate is well formed, or digest on a steam-bath over night. Set aside over night or for a few hours, filter through a prepared Gooch crucible, ignite gently, and weigh as barium sulfate. Calculate to sodium sulfate, or the alkaline sulfate known to be present.

XIV. Determination of Glycerin, Sugar, and Starch.—(1) *Determination of glycerin in the absence of sugar.*

Solutions Required

Potassium dichromate, 74.552 g. per liter
Sodium thiosulfate, 0 1 *N*
Potassium iodide, 10 per cent.

Dissolve an accurately weighed sample of the soap[2] equivalent to not more than 3.0 g. of glycerin in 200 c.c. of hot water in a 600-c.c. beaker. Decompose with 25 c.c. of sulfuric acid (1:4). If alcohol is present, volatilize it by boiling for 20 to 30 min. Cool, remove, and rinse the cake of fatty acids, transfer the acid water and rinsings to a 500-c.c. graduated flask, add about 0.25 g. of silver sulfate to precipitate traces of chlorides and soluble fatty acids. Make up to volume and mix contents thoroughly.

Transfer a filtered, accurately measured 50-c.c. aliquot of the above to a 400-c.c. beaker, to this add 75 c.c. of accurately measured potassium dichromate solution, followed by 25 c.c. of sulfuric acid (sp. gr. 1.84). Cover with a watch glass, and oxidize by heating in a steam-bath for 3 hrs. Conduct a blank in like manner but using 100 c.c. of water, 25 c.c. of sulfuric acid (sp. gr. 1.84), and 25 c.c. of accurately measured potassium dichromate.

Cool and make up the solution to 1000 c.c. in graduated flasks. The excess of potassium dichromate is determined by taking 50 c.c. aliquot of the above, adding 50 c.c. of water, 20 c.c. of 10 per cent. potassium iodide solution, and titrating the liberated iodine with 0.1 *N* thiosulfate, using starch solution as indicator.

Calculate the percentage of glycerin (1 c.c. of the potassium dichromate solution equals 0.0100 g. of glycerin).

(2) *Determination of sugar.*[3] Dissolve 10 g. of the soap in 200 c.c. of hot water in a 600-c.c. beaker. Decompose with 25 c.c. of sulfuric

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[13] Evaporation to dryness is unnecessary unless gelatinous silica should have separated, and should never be performed on a bath heated by gas. See Hillebrand, *U. S. Geological Survey Bulletin* **700**, 232.

[2] If starch is present, it will be necessary to remove the matter insoluble in water as described under this determination [II (1) and (3)]. Combine the alcohol and water solutions, evaporate off the alcohol, and proceed.

[3] If starch is present, see determination of starch XIV(4).

acid (1:4), boil gently for 20 min. to invert the cane sugar completely. Cool, remove, and rinse the cake of fatty acids. Extract the acid liquid with 25 c.c. of ether. Transfer the acid liquid to a 500-c.c. graduated flask, make up to volume and mix thoroughly. Determine invert sugar in 50 c.c. of this solution by the Munson-Walker Method.[1] To calculate sugar (sucrose), multiply the amount of invert sugar found by 0.95.

(3) *Determination of glycerin in the presence of sugars.*[2] Proceed as above under (1), taking a sample so that the sum of the glycerin and sugar is not more than 3.0 g.[3] The solution must be boiled in all cases at least 20 min. to insure complete inversion of cane sugar. Determine the amount of potassium dichromate solution required to oxidize both the sugar and glycerin. Determine also the sugar by the method given in (2).

Calculate the percentage of glycerin after deducting the amount of potassium dichromate required by the sugar.

1 c.c. potassium dichromate equals 0.0100 g. glycerin.

1 c.c. potassium dichromate equals 0.01142 g. invert sugar.

(4) *Determination of starch.*[4] Separate the matter insoluble in water as under II(3), using a sample of soap that will give not more than 3 g. of starch. Transfer the insoluble matter, without drying, to a beaker and heat for 2½ hrs. with 200 c.c. of water and 20 c.c. of hydrochloric acid (sp. gr. 1.125) in a flask provided with a reflux condenser. Cool, and nearly neutralize with sodium hydroxide. Complete the volume to 250 c.c., filter, and determine the reducing sugars by the gravimetric method, as given under method for the determination of sugar.

Calculate the amount of dextrose (*d*-glucose) equivalent to the cuprous oxide obtained. This multiplied by 0.90 equals the amount of starch.

XV. Volatile Hydrocarbon.—Weigh not less than 250 g. of the sample into a flask of about 5-liter capacity, which is so placed on a gauze that it can be heated. Add 2 to 3 liters of distilled water. Place a 2-holed rubber stopper in the flask, through one hole of which is inserted a copper or brass tube extending into the flask and terminating in a small circular ring of the tubing, bent so that the ring is in a horizontal position. Numerous small holes are drilled in the upper side of this ring and the end of the tube is sealed. This ring should be near the bottom of the flask.

Through the other hole of the stopper is inserted a glass tube provided with a trap of suitable form, the upper end of which is bent so as to be connected with a plain Liebig condenser. The end of the condenser tube is bent so as to extend into a buret graduated to 0.1 c.c.

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[1] *Journal of the American Chemical Society*, **28** (1906), 663; *Bureau of Chemistry Bulletin* **107**; "Methods of Analysis of Association of Official Agricultural Chemists," **1920**, 78.

[2] Hoyt and Pemberton, *Journal of Industrial and Engineering Chemistry*, **14** (1922), 54; correction, **14** (1922), 340.

[3] See 2, p. 53, if starch is present.

[4] "Methods of Analysis of Association of Official Agricultural Chemists," **1920**, 95; *Bureau of Chemistry Bulletin* **107**, 53.

Introduce steam (free from oil) into the flask through the brass tube and collect the distillate in the buret. When the buret becomes full, draw off the water by opening the stopcock. The foam which forms in the flask may be controlled by momentarily shutting off the steam and by regulating heat applied to the flask.[1]

Read from time to time the amount of hydrocarbon distillate which collects on the top of the water in the buret, and when there is no further increase in this distillate the operation is finished. Allow the buret to stand over night, tightly stoppered, and then, after reading the amount of distillate, draw off the water as carefully as possible. Determine the specific gravity of the distillate, and calculate the weight and percentage in the original sample.

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[1]Some find it an advantage to add 200 to 300 g. of calcium chloride to the flask containing the soap solution, to prevent foaming.

CHAPTER IV

BLEACHING

Bleaching from the laundryowner's viewpoint is entirely different from that of the textile manufacturer. In the final analysis, the latter has to deal with materials in the raw or unbleached state. In such a condition, they contain a quantity of waxy and resinous compounds with which the laundryowner seldom, if ever, deals. These are removed in the kier-boil, while the small amounts of coloring matter naturally present in the fibers are rendered colorless or soluble in water by the subsequent bleach. The laundryowner, however, is required to study bleaching from the viewpoint of the finished rather than the unfinished material. For instance, the fabrics with which he deals, if white, have been bleached before, unless they consist of certain types of unbleached towelling, muslin, etc. This point should always be borne in mind, for bleaching repeated too often, and especially if uncontrolled, will tender vegetable fibers greatly, as will be shown later.

For a material to be a bleach, it must be either an oxidizing or a reducing agent. If it is an oxidizing agent, it must be able to add oxygen to the coloring matter present in the fiber, changing it to an entirely new substance that is colorless or is soluble in water. If it is a reducing agent, it must be able to remove oxygen from the coloring matter and, by so doing, render it colorless or soluble in water.

Of the materials that are classed as oxidizing agents, there are some which are suitable for either acid or alka-

line solutions, but with different degrees of effectiveness. As an example, potassium permanganate will give up 2½ units of oxygen in acid solution, while in alkaline baths it will give up only 1½.

There are other oxidizing agents that are not suitable for use in alkaline solutions, an example of which is sodium dichromate, a material found in one bleach (so-called) which has been offered to the trade.

There is still another class of oxidizing bleaching agents, which, because of poor stability in acids, are suitable for use only in alkaline solutions. Examples of this group are found in the common and most extensively used laundry bleach, sodium hypochlorite or Javel water, and in such materials as sodium perborate and sodium percarbonate.

Preparation of Sodium Hypochlorite or Javel Water from Chloride of Lime and Soda Ash.—For many reasons it is necessary in laundry practice to employ a bleach that is suitable for use in an alkaline bath, especially in the bleaching of fabrics of vegetable origin, such as cotton and linen. It is also necessary that a bleach liquor used in laundry practice be free from any elements that form insoluble soaps, notably calcium (lime) and magnesium. Raw bleaching powder, which is calcium hypochlorite, should not, therefore, be used. Bleaching powder treated with a sufficient quantity of sodium carbonate yields sodium hypochlorite, precipitating the calcium as calcium carbonate, which may be settled out, leaving a clear, soft (that is, free from soap-destroying elements) bleach liquor generally called Javel water. The reaction may be represented as follows:

$CaCl.OCl$	+	Na_2CO_3	$\rightleftharpoons$	$NaOCl$	+	$NaCl$	+	$CaCO_3$
(Calcium hypochlorite)		(Sodium carbonate)		(Sodium hypochlorite)		(Sodium chloride or common salt)		(Calcium carbonate) (insoluble)

At the present time, sodium hypochlorite, made in one way or another, is a material that fulfills these conditions. The choice as to the way it is prepared is purely one of cost. A solution prepared by using 10 pounds of bleaching powder of a strength of 35% available chlorine, 10 pounds of soda ash and 30 gallons of water will contain, theoretically, 1.4% of available chlorine, or 14 grams per liter. In practice, bleach solutions prepared as just outlined, will seldom contain much over 1% of available chlorine. This solution will also contain some sodium chloride as a necessary by-product of the reaction, some sodium hydroxide formed by the reaction of sodium carbonate with the slight excess of calcium hydroxide, which is an impurity incident to the process of manufacturing bleaching powder, and some sodium carbonate, which is added in slight excess to insure the complete precipitation of the calcium.

Arrangements for Siphoning Javel Water to Obtain a Clear Solution

The device as illustrated by the following sketch was first seen in the Highland Laundry, Boston, Mass. The apparatus at this plant was provided with a mechanical stirrer to agitate the mixture during the precipitation process, but for the sake of simplicity this feature, though a good one, is not described here.

Purpose.—It is a matter of common observation that, after the bleaching powder is mixed into water and the calcium is precipitated by means of sodium carbonate, the surface of the liquor is covered with a scum of solids which, because of entrained bubbles of gas, are only with great difficulty caused to settle to the bottom of the container. Because of this condition, it is difficult to avoid getting the objectionable lime into the solution and

into the "wheel" when the stock liquor is dipped, as used, from the container in which it was made.

One obvious way to overcome this difficulty is to strain the liquor through a cloth before adding it to the bleaching bath in the wheel. This, however, requires a considerable amount of care when the washman is busy. Then, too, the strainer cloth is quickly corroded unless the time-consuming precaution of rinsing it carefully each time it is used is observed. In some plants a stockkeeper is made responsible for the preparation of the stock bleach liquor, and only clear liquor is delivered to the washroom.

The arrangement herein described accomplishes the desired result of clear bleach-liquor very efficiently and almost automatically.

Description.—"A" represents stoneware jars of suitable capacity, 30 gallons being a customary size for the formula, 10 pounds of bleaching powder, and 10 pounds of 58 per cent. soda ash to 30 gallons of water.

One jar is mounted on a bench or table of such a height that the bottom of the elevated jar is somewhat higher than the top of the one on the floor which is to receive the clear liquor. It is desirable in some instances to have room on the bench or table for two jars in order that one batch may be made up and allowed to settle while the other is being siphoned.

"C" is a float made of a six-inch length of a 2 x 4-inch piece of wood. Through the center of this piece of wood should be bored a hole, through which may be snugly fitted a four-inch piece of ¼-inch glass tubing, one inch of each end projecting from the surface of the block of wood. After the tubing is in place, the float should be painted with melted paraffin. (The paraffin should not be hotter than 212° F. when applied; otherwise the paint brush may be destroyed.)

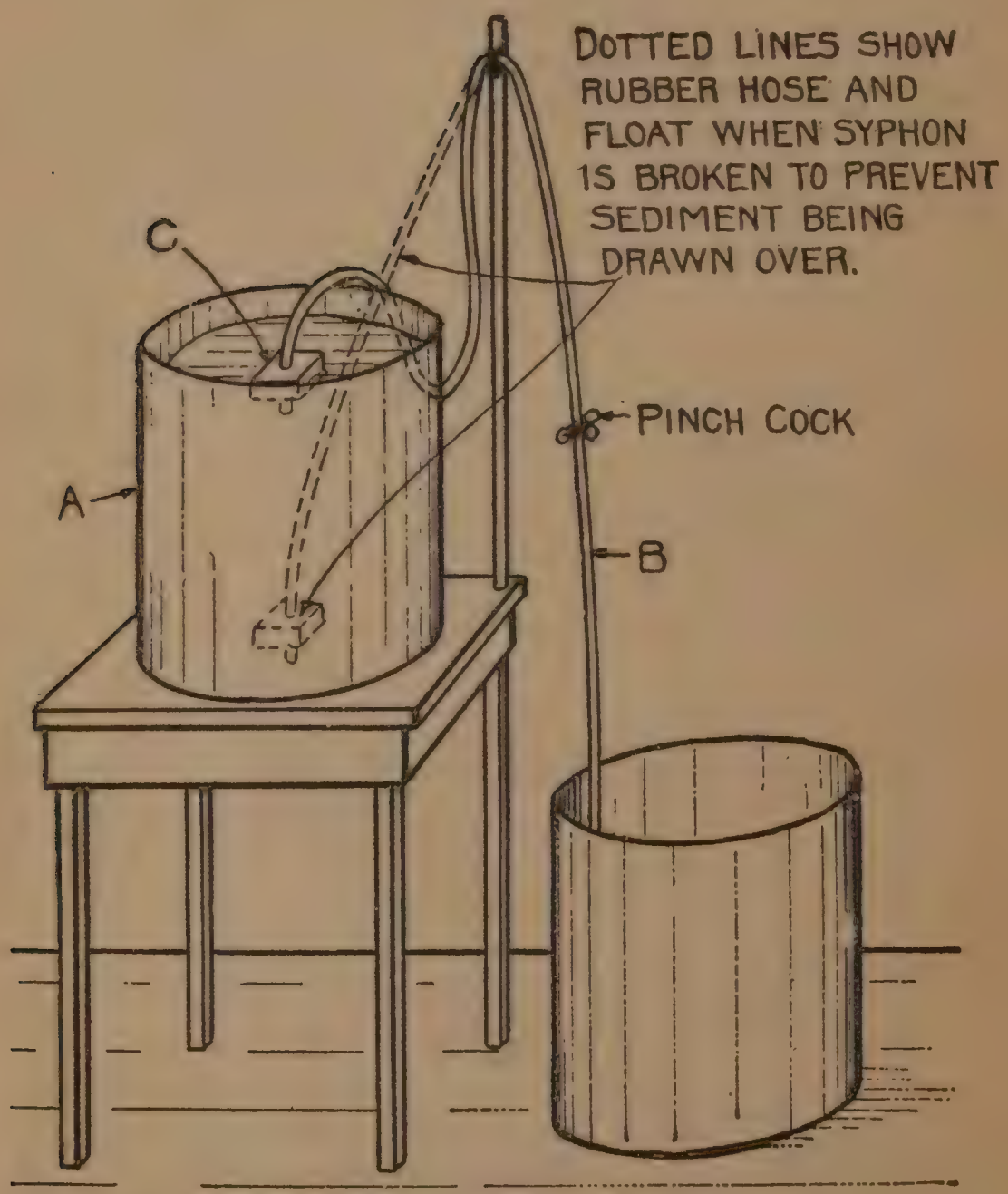

FIG. 1—APPARATUS FOR SIPHONING BLEACH LIQUOR

"B" is a six-foot length (length depending on height of jar) of ¼-inch rubber tubing, one end of which is fitted over the glass tube in the float and so supported that the tube will slide readily over the edge of the jar as the float lowers with the surface of the liquid. The other end of the tube is sufficiently long to discharge into the lower container, when the syphon is started. The length of the rubber tube, from the float to the point of support above the elevated jar, should be just sufficient to lift the float from the liquid and break the siphon just before the surface of the liquid reaches the sediment in the bottom of the jar.

To Prime the Siphon.—To prime the siphon, fill the rubber tube with water and close near the discharge end with a spring pinch-cock. Then place the float on the surface of the settled liquor and release the pinch-cock and allow the clear liquor to flow into the lower jar.

Materials.—The apparatus mentioned above, the glass tubing, the rubber tubing, and pinch-cock can be secured usually at a local drug store or from dealers in chemical supplies.

Purchase Specifications of Bleaching Powder.—In the textile trade, bleaching powder is usually sold on a 35 per cent. available chlorine basis. This should be the case in the laundry trade. The bleaching powder varies a great deal in its available chlorine according to the care exercised in its manufacture, packing and shipping; hence it is important to know exactly how much available chlorine is being purchased with each 100 pounds of bleaching powder. For an arithmetical example, if one is able to buy 35 per cent. available chlorine bleaching powder for $3.50 per hundred-weight, one could afford to pay for bleaching powder containing 25 per cent. available chlorine only 25/35 of $3.50, or $2.50 per hundred-weight.

Laundry Bleach from Liquid Chlorine.—A bleaching solution of about the same strength (about 1% available chlorine) as the one prepared by the chloride of lime-soda ash formula may be made by one of the following two formulas:

30 gallons of water,
11½ pounds of soda ash (58% Na_2O),
3.8 pounds of liquid chlorine;

or

30 gallons of water,
4.3 pounds of caustic soda (76% Na_2O),
3.8 pounds of liquid chlorine.

Since the three formulas given for preparing bleach will yield equal volumes of bleach solution of about the same strength, it may be determined easily which method is the cheapest in any particular locality. The cost of materials that are used varies somewhat with the locality as well as with the quantity in which they are bought.

Preparation of a Bleach Liquor of About 5% Available Chlorine Strength.—If it is desired to prepare a fairly concentrated bleach solution, the following formula may be used:

50 gallons of water,
27.7 pounds of caustic soda (76% Na_2O),
1.5 pounds of soda ash,
21.8 pounds of chlorine gas.

This formula will yield a bleach liquor of about 5 times the strength of that prepared by the chloride of lime-soda ash formula as prescribed by the L.N.A.

It is needless to say that when a bleach liquor having a strength of 5% available chlorine is used, only 1/5 as much of it should be applied to any given load as would be required if a bleach liquor containing only 1% chlorine were used.

A small amount of soda ash is added to this formula

in addition to the caustic soda for the reason that the soda ash is said to stabilize the bleach solution.[1]

Construction of Bleach Tank.—The container may be a large earthenware crock or if desirable it may be made of concrete, although it hardly pays to build a concrete container of only 30 gallons capacity. If crocks are not available for the purpose, a container may be made by setting in a concrete base a piece of sewer pipe of suitable size. The container should have an approximate diameter of 20 inches with a height of about 30 inches. The relative depth of soda solution will absorb the chlorine gas which is bubbled in at the bottom. If the solution is too shallow the gas may escape from the surface of the liquid.

Bleach solution should be used within two or, at the most, three days after it has been prepared. There are laundries where more than thirty gallons of bleach solution of 1 per cent. to 1.2 per cent. available chlorine are required for a two days' supply. The amount of solution prepared at any one time must, therefore, be determined by the requirements and the size of the bleach tank designed accordingly.

The chlorine is introduced into the soda solution through a lead pipe, which extends from about a foot above the surface of the bleach liquor to the bottom, and across the bottom of the tank. The lead pipe across the bottom of the tank should be perforated with pin holes about one-half inch apart, along its entire length (see Fig. 2).

The cylinder of chlorine may be placed on a platform-scale, so that the loss in gross weight of the cylinder, as the gas is bubbled into the solution, will represent the amount of chlorine being used.

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[1] "The Preparation of Concentrated Sodium Hypochlorite Solution of Great Stability for Use in Food Factories, Milk Plants, etc.," by Harper F. Zoller, *Industrial and Engineering Chemistry*, August, **1923**.

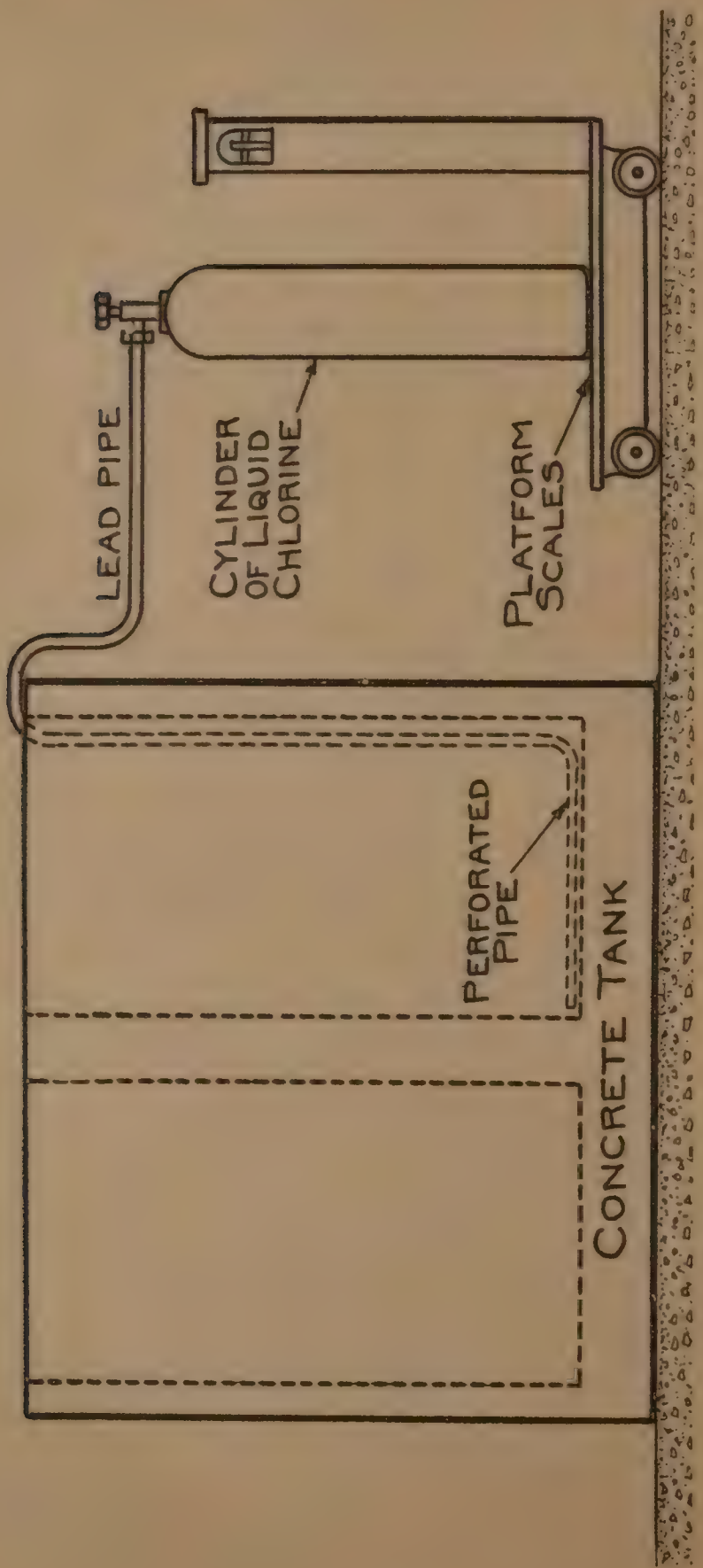


FIG. 2—APPARATUS FOR MAKING BLEACH FROM LIQUID CHLORINE

If desirable, the cylinder of chlorine may be kept at a considerable distance from the bleach tank, having an iron pipe running from the cylinder to within a few feet of the bleach solution. Chlorine gas, when dry, is not injurious to iron.

Physical Properties of Chlorine.—Chlorine, under ordinary atmospheric conditions, is a gas but it becomes a liquid at 32° F. under about one hundred pounds pressure. It is in the liquid state that chlorine is put into cylinders so that it can be distributed for use. Chlorine gas is heavier than air and will, therefore, not pass upward through a flue except under a forced draft. The gas, even in small concentration in the air, is very injurious to the throat and lungs. It has also, in moist air, a very damaging effect on fabrics and the metal parts of machinery. For these reasons, the chlorine cylinders should be stored outside the laundry proper. One can never foretell when the valve on a cylinder may leak so as to let the gas escape into the atmosphere.

Hypochlorite from Soda Ash and Liquid Chlorine.—The reaction between soda ash and liquid chlorine proceeds as follows:

$$\underset{\text{(Soda ash)}}{2Na_2CO_3} + \underset{\text{(Chlorine)}}{Cl_2} + \underset{\text{(Water)}}{H_2O} = \underset{\text{(Sodium chloride)}}{NaCl} + \underset{\text{(Sodium hypochloride)}}{NaOCl} + \underset{\text{(Sodium bicarbonate)}}{2NaHCO_3}.$$

The soda ash is dissolved in the water. No spontaneous heating takes place as the soda ash goes into solution. After all of the soda ash has been dissolved, the chlorine is introduced by gently bubbling it into the bottom of the solution through the perforated lead pipe. The advantage in using soda ash in preference to caustic soda, is that the reaction between soda ash and chlorine does not generate heat in the manner of caustic soda and chlorine. The solution will not fume nor heat up and therefore the operation of making the bleach is easily performed without any disagreeable circumstances.

One precaution is to be observed: No excess of chlorine dare be used, over that specified in the formula, or violent effervescence of the solution may set in, for the reason that the chlorine will attack and decompose the sodium bicarbonate with the liberation of carbon dioxide, according to the equation

$$NaHCO_3 + Cl_2 = NaCl + CO_2 + HOCl.$$

Caustic Soda and Liquid Chlorine Method.—When caustic soda is used for making the bleach, this reaction takes place:

2 NaOH	+	2 Cl	=	NaOCl	+	NaCl	+	H_2O.
(Caustic soda)		(Chlorine)		(Sodium hypochlorite)		(Sodium chloride)		(Water)

The formula as listed allows for a slight excess of caustic soda over that required by the chlorine which is introduced. This excess of caustic soda is allowed to give the bleach solution greater stability than is possessed by a perfectly neutral bleach. Too great an excess of free alkali in the bleach must, however, be avoided for such a condition would render the bleach so stable that its usefulness as a bleach would be materially lessened.

It is equally important that an excess of chlorine be avoided, for this would make an acid bleach, one that is dangerously active and exceedingly unstable. When caustic soda is dissolved in the water, the solution becomes warm and should be allowed to cool before the chlorine is introduced. If the chlorine is not added slowly, the solution will heat up again and cause decomposition of the bleach. The temperature of the solution should always be kept under 80° F.

Electrolytic Bleach Solutions.—The method of making bleach liquor by the electrolytic process has always made a strong appeal to many laundryowners. This process for preparing bleach, when properly controlled, is

a simple one and consists of passing a direct current of electricity through a solution of sodium chloride (common salt), thereby forming a solution of sodium hypochlorite (bleach). Not all of the salt is converted into bleach, a considerable amount of it remaining as salt. Electrolytic bleaches are always slightly alkaline due to the formation of some caustic soda.

When sodium chloride is in solution in water it ionizes

$$\underset{\text{Sodium chloride}}{NaCl} \rightleftarrows \underset{\text{Sodium ion}}{Na^+} + \underset{\text{Chlorine ion}}{Cl^-}$$

into sodium ions which have a positive charge and into chlorine ions which have a negative charge. As the direct current passes through the solution, the positive ions (Na^+) are attracted to the negative electrode (cathode), while the negative ions (Cl^-) are drawn to the positive electrode (anode). The sodium formed from the discharged ions reacts with water,

$$2\,Na + 2H^+ + OH^- \rightarrow 2\,NaOH + H_2,$$

to form caustic soda and hydrogen gas. The gas escapes into the atmosphere. The chlorine which was formed reacts with the caustic soda,

$$2\,NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2O,$$

forming sodium hypochlorite (bleach), salt and water.

The above reactions are the primary and important ones connected with the production of electrolytic bleach. There are other secondary reactions taking place which may interfere seriously with the quality of the bleach. The electrolytic cell has a tendency to get hot when current passes through it, thus favoring the formation of sodium chlorate. Poor circulation of the liquor in the cell is also conducive to the formation of chlorates.

There are several different types of electrolytic cells on the market and each of them has its own peculiarities as to construction and degree of efficiency. In a gen-

eral way it may be said that, when a laundry generates its own direct current and when it is certain that an electrolytic cell would be given the careful attention necessary for efficient and satisfactory operation, the electrolytic method is satisfactory for preparing bleach liquor.[1]

The Effect of Bleaching Cotton and Linen Fabrics with Hypochlorite.—It is well known that silks and woolens should never be bleached with hypochlorite for the reason that these two fibers are strikingly damaged by the hypochlorite. There are no exceptions to this statement.

Although the power laundry industry has always bleached cotton and linen fabrics, it does not necessarily follow that hypochlorite is harmless to these vegetable fibers. Hypochlorite is a bleaching agent by virtue of its ability to destroy certain colors, but by this same power it may also destroy the cotton and linen fiber when improperly applied.

There are three factors which have an appreciable influence on the effect of sodium hypochlorite upon cotton and linen fiber.

The concentration of the bleach with respect to the quantity of goods to be bleached must be carefully considered. P. Heermann and H. Frederking[2] have shown that when cotton cloth was immersed for 15 minutes, in 15 times its weight of a solution of calcium hypochlorite at 20° C., after 50 immersions there was a loss in tensile strength, at the different concentrations as follows:

(a) Concentration of Bleach	% Loss in Tensile Strength
0.5 gram per liter	9 %
1 gram per liter	35 %
2 gram per liter	59.8%

[1]Matthew's "*Bleaching and Related Processes*, 1921
[2]*Chemical Abstracts*, **16**, 2415.

It will be noticed that there was quite an appreciable reduction in the tensile strength of the cloth due to the bleach even at the low concentration of 0.5 gram of available chlorine per liter. This test was made with the bleach solution at room temperature.

(b) When in the preceding test the temperature was raised from 20°C. to 27.5°C., the loss in tensile strength was almost doubled.

(c) When in the preceding test the time was extended from 15 minutes to 75 minutes, the loss in tensile strength was 15.7% instead of 9% after fifty immersions.

These data show conclusively that bleaching may very easily be overdone in the washroom and that in most cases 10 minutes is the maximum time which should be allowed for this operation. In fact, the bulk of all the textiles which come to the laundry need not be bleached at all. There are cases, however, in which bleaching must be resorted to in order to thoroughly cleanse the goods. Table linen, for example, which has been heavily stained must usually be bleached in order to destroy some of the stains which do not come out in the suds. A sample of unbleached muslin will have been bleached to a satisfactory white after about 12 launderings by the L.N.A. formulas.

The foregoing data emphasize the necessity of bleaching as lightly as possible to be in keeping with the best information at our disposal.

Perborates and Percarbonates as Bleaches.—It has been shown[1] that, when samples of cotton and linen cloth were washed 50 times with soap and soda and also with soap containing 10 per cent. of perborates, the losses suffered by the samples were as follows:

[1] P. Heermann, *Mitteilung aus dem Materialprüfungsamt*, 1921.

Samples Washed in	Loss in Breaking Strength	
	Linen	Cotton
Soap and soda ash	10½%	5½%
Soap and perborate	56%	35%

Furthermore, after 10 washings in a 1% solution of sodium perborate the linen samples had lost 56% in breaking strength and the cotton had lost 40% in breaking strength. It is to be noted that linen suffered greater losses than the cotton cloth in the above tests.

Perborates and percarbonates are not being used in this country as laundry bleaches and, according to the report of Heermann, they should not be used in conjunction with soap in the concentration mentioned, if they should be used at all.

Necessity of a Bleaching Agent.—The conclusion has been reached as the result of extensive investigation into the chemistry of laundering that bleach and certain sours are the most harmful on fabrics of all the washroom reagents. While any oxidizing bleach must be more or less harmful, its effect when used intelligently is not as great as might be imagined and is, in fact, of about the same magnitude as that of mechanical influence. This effect has been sometimes exaggerated, and some writers have advocated that the bleaching be omitted. We are not prepared to go so far as this in our advice but we are convinced that in many instances bleaching can be omitted without serious depreciation in the appearance of the work. The conviction is based on an experiment, conducted in this laboratory, on a certain lot of goods, extending in time over a period of ten months. This conviction is further strengthened by observation of the work in plants where a proprietary bleach, in which we could detect no oxidizing power, had been used.

It should be borne in mind that a bleach has a definite value for certain stains. Among these are grass,

wine, fruit and other food stains. For the treatment of many other stains oxidizing bleaches are not only of no advantage but are actually of disadvantage, as is the case, for example, with iron stains. Obviously there are many classes of goods sent to the laundry in which the stains mentioned above are rare and the bleaching could be omitted with no ill effect on the appearance of the work. From experiments conducted by this Department, it is quite clear that the use of a moderate quantity of sodium hypochlorite or Javel water is not the destructive treatment that might be inferred from some of the statements in the literature, and that, in case of the stains mentioned above, its use offers the most effective and least harmful method of restoring the original whiteness. In all events, however, temperature and concentration must be controlled accurately.

This suggestion may be brought before those who wish to dispense with bleach on certain lots of goods; that is, the souring may be continued for two or three times after the bleaching has been discontinued and then both may be omitted. This is a matter of experience. It is in harmony with chemical fact that sodas react with oxycellulose to form a colored compound. After two or three treatments the oxycellulose will be less in evidence and then the sour will not be required.

Metallic Dirt and Sodium Hypochlorite.—It has been proved that one of the great differences in the degree of deterioration between clean and soiled portions of a fabric is due to the presence of metallic impurities in the dirty parts which make the bleach much more active. Mere traces of copper in the fibers may cause holes in a fabric in a single washing, due to the localized accelerated action of bleach. This fact bears an interesting correlation to the fact that Javel water cannot be stored in a copper or monel metal container for the reason that

the bleach solution decomposes very rapidly due to the catalytic action of these metals on it. It is, therefore, imperative that metallic stains due to "verdigris" from brass or monel metal washers should not be allowed to accumulate on a fabric. Javel water in contact with such "verdigris" stains on a fabric is very destructive to the textile fibers.

Manganese, also, has a strong catalytic effect on Javel water, but iron is much weaker in this respect. It takes a long time for rust spots to eat their way through a fabric.

Reducing Bleaching Agents.—Reducing bleaching agents have their application in the textile trade more extensively than in the laundry industry. Among the important ones are sodium bisulfite and oxalic acid. The bleaching properties of sodium bisulfite are worthy of some emphasis. The active properties of this material are due to sulfurous acid (do not confuse with sulfuric acid), which is the effective agent employed in bleaching woolens by the so-called sulfur stoves or "stoving" process. The only important difference between this material and sulfurous acid gas (SO_2 sulfur dioxide), obtained from burning sulfur, is that sodium bisulfite is more conveniently transported and handled, a fact that constitutes a very great advantage. Many of the vegetable stains are readily bleached by sodium bisulfite, and we have in it a combined bleach and sour, in addition to the advantage that it is very much less harmful to cotton and linen fabrics than are oxidizing bleaches. It may be used safely on silks and woolens.

Summary.—To summarize, then, it may be said that sodium hypochlorite, or Javel water, is, according to present knowledge, the most practical bleach to use. It should be emphasized that the stock bleach liquor is properly called sodium hypochlorite or Javel water, and

that while it may be, and usually is, prepared from bleaching powder, there is in the properly prepared liquor no lime. It should not therefore be referred to as lime-bleach. Because of the false impression arising from the use of the latter expression and because the term is incorrect, its abandonment is sincerely urged. The name "Javel water" is accepted in technical literature and more recently, through domestic science publications, it is becoming more established in popular literature.

Bleach liquor, or, adopting the above expression, Javel water, should be prepared in the laundry by one of the three methods previously mentioned, the choice depending only on the cost and convenience of the particular method.

While from the chemical properties of "Javel water" it is known that if used in excessive amounts it is destructive to cotton and linen, yet experiments prove that if used moderately the harmful action is almost negligible when compared with the effect of friction and the necessary steps of laundering, either at home or in the power laundry.

EXPERIMENTAL PART FOR STUDENT

1. **Preparation of a Soft Bleach.**—Prepare a bleaching solution (see page 58), by dissolving 5.3 oz. of 58% soda-ash in 1 gallon of water. Then stir into the solution 5.3 oz. of chloride of lime which has been mixed into a thick paste with water. Allow the batch to stand over night. After this time has elapsed the hypochlorite will have changed from calcium hypochlorite to sodium hypochlorite in accordance with the reaction

$$Ca\begin{matrix}\diagup\ OCl\\ \diagdown\ Cl\end{matrix} + Na_2CO_3 = NaOCl + NaCl + CaCO_3.$$

The insoluble calcium carbonate will have settled out so that the supernatant solution of sodium hypochlorite may be poured or siphoned from it.

Hypochlorite bleach is used in the laundry as sodium hypochlorite for the reason that if the calcium compound were added to the wash wheel, the undesirable calcium soap would be formed. In other words, calcium hypochlorite is a "hard" bleach, while sodium hypochlorite is a soft bleach.

2. **Effect of Bleach.**—Select three pieces of muslin cotton sheeting, about 6 inches square. Immerse two pieces for a few seconds in the bleaching solution just prepared. Remove the samples from the bleach solution and rinse one of them thoroughly under the tap. Simply squeeze the bleach solution from the other sample without rinsing it. Now dry both samples in the oven, at 105° C. for 15 minutes. Do not allow the two samples to be in contact with each other if placed in the oven.

After removing the samples from the oven compare the untreated and the two treated samples for tensile strength. If a tensile strength apparatus is not available, the test may be performed by pulling the samples with the hands. The sample which was immersed in the bleach but not rinsed will be noticeably weak.

Repeat this test but iron the samples dry with a hot flat iron instead of placing them in an oven.

3. **Qualitative Test for Starch.**—This test is based upon the action of iodine on starch. Upon a peeled portion of a raw potato place a drop of tincture of iodine. The purplish blue color which develops is characteristic of the action of iodine on starch.

b. Dissolve about 1 gram of potassium iodide in 100 c.c. of water, and then add 3 c.c. of concentrated acetic acid. Add five c.c. of starch solution.[1] Now add a few drops of a solution of hypochlorite. Note the color change.

How would you test a solution for the presence or absence of hypochlorite?

4. **Action of Bleach on Stains.**—Stain portions of cotton sheeting with the following: coffee, tomato juice, and peach juice. Allow the stains to dry. Apply bleaching solution to the stains. What is the effect?

5. **Bleaching.**—Immerse a piece of unbleached muslin in a bleach solution containing 1% available chlorine at room temperature. After about 10 hours or more remove the sample and rinse it thoroughly. Describe the effect.

[1]For qualitative purposes a 1 per cent. solution of a boiled laundry starch is satisfactory.

QUESTIONS TO BE ANSWERED

1. Why is a bleach used in laundering?
2. Should colored goods be bleached?
3. Should bleach ever be used on wool or silk?
4. Is bleach destructive to cotton and linen?

QUANTITATIVE ANALYSIS OF HYPOCHLORITE BLEACH

Starch Solution. Rub 5 grams of potato starch with cold water to a thin paste. Pour into 1 liter of boiling water and boil for fifteen minutes. Keep the solution in a glass stoppered bottle. It should not be kept longer than a month.

If a "thin boiling" laundry starch is used, the boiling need not be continued for more than 5 minutes.

Sodium arsenite. 0.1 N arsenious acid (4.948 grams As_2O_3 per liter).

Dissolve 4.96 grams of the purest sublimed As_2O_3 powder in about 250 c.c. of distilled water in which has been dissolved about 20 grams of pure soda-ash. The mixture needs warming and shaking for some time to complete the solution. When the solution is clear, cool and make up to 1 liter at 20° C.

When pure As_2O_3 is used the solution is, for experimental purposes, sufficiently close to 0.1 N strength to make standardization unnecessary. If it is desired to standardize the solution absolutely, it should be titrated against a 0.1 N standard iodine solution and a publication on standard methods of analysis should be consulted.

On adding arsenious acid to a solution of sodium or calcium hypochlorite the former is oxidized while the latter is reduced.

$$2\ NaOCl + As_2O_3 = As_2O_5 + 2\ NaCl.$$

The end point is reached when a drop of the solution added to a piece of iodo-starch paper will produce no blue color.

1000 c.c. N/10 As_2O_3 = 3.546 grams chlorine.

The arsenite solution is of such strength that each c.c. used is equivalent to 0.00355 gram of available chlorine.

Method of Procedure. Iodized strips of starched collars or potassium iodide-starch paper are used as the indicator. These are prepared as follows: Place one or two crystals of potassium iodide (size of a grain of rice) in a beaker and add one tablespoonful of clear water. When the crystals have dissolved, dip into the solution 10 or 12 narrow strips cut from a clean starched collar. When the strips are thoroughly wet, lay them out on a clean sheet of white paper.

(a) To test electrolytic bleach: By the use of the pipette, measure into a beaker 35 c.c. of the solution to be tested. Fill burette No. 1 to the zero mark with sodium arsenite solution, then run reagent into a beaker, a few c.c. at a time, stirring the solution under assay with a glass rod. By means of the glass rod, convey one drop of the solu-

[1]There is another method which recommends that the starch and potassium iodide indicator be added directly to the bleach solution to be titrated. It has been observed in this laboratory that the end point is not easily detected when that procedure is followed.

tion being tested to one of the iodized collar strips; if a considerable amount of available chlorine is still present, the strip will be turned a dark blue color. Then add a few c.c. of arsenite solution and again apply a drop of the solution from the beaker to a fresh test strip of collar. This procedure should be cautiously repeated, adding 1 c.c. at a time, till no color is produced on the test strip by one drop of the solution under test. The reading of the burette represents, for each c.c. of arsenite solution used, 1/100 per cent. of available chlorine in the bleach liquor being tested. Thus, if the burette reading is 30 c.c. the strength of the bleach liquor is 0.30 per cent.

(b) To test stock bleach liquor made from bleaching powder and soda or soda-ash: Proceed as for electrolytic action, with this exception: 3.5 c.c. should be measured out into a beaker with the result that each c.c. of arsenite solutions used represents 1/10 per cent. of available chlorine in the bleach liquor. Thus, if 14 c.c. of arsenite solutions are required, the strength of the bleach liquor will be $1/10 \times 14 = 1.4$ per cent. of available chlorine.

Bleach (Bleaching Powder).[1] Available Chlorine.—Mix the whole sample quickly and thoroughly, discarding the outside (top layer) which has lost more or less chlorine. Weigh out from a weighing bottle about 10 grams into a porcelain mortar, add a little water and rub the mixture to a smooth cream. Then stir in more water with the pestle, let settle for a few moments and pour off through a funnel into a liter flask. Again rub the sediment with water and pour off as before. Repeat the operation until the whole of the material has been conveyed into the flask without loss and the mortar washed clean. Then fill the flask to the mark with water, mix well and pipette out immediately, without allowing the material to settle, 50 c.c. into a beaker. Add 50 c.c. of 0.1 N arsenious acid. Stir the mixture well and then titrate back the excess of arsenious acid with 0.1 N iodine, adding a little starch indicator. Duplicate determinations should always be made. From the amount of As_2O_3 consumed calculate the average Cl in the bleach.

Calculation.—1 c.c. 0.1 N $As_2O_3 = 0.003546$ gram Cl.

Notes. (1) It is generally specified that a good bleaching powder should contain not less than 35% of available chlorine.

(2) A good bleaching powder when mixed with water in the proportion of 6 parts of bleach to 94 of water and stirred thoroughly for about twenty minutes, should settle clear in not more than an hour.

[1]Griffin, "Technical Methods of Analysis," p. 312.

CHAPTER V

SOURS

The term "sour" has been borrowed from the textile industry. It is applied logically, in that all substances that have a sour taste are either acids or react with water in which they are dissolved to form acids. Acids react with alkalies to form new compounds and water. For example, sodium hydroxide treated with acetic acid forms sodium acetate and water, the reaction being represented by the following expression:

$$\underset{\text{(Sodium hydroxide)}}{NaOH} + \underset{\text{(Acetic acid)}}{CH_3COOH} \rightleftarrows \underset{\text{(Sodium acetate)}}{CH_3COO.Na} + \underset{\text{(Water)}}{H_2O}.$$

The process represented in this equation is called neutralization, because the properties of the alkali and the properties of the sour are entirely destroyed by adding the required amount of one to the other.

Weak and Strong Sours.—Fifty-three parts by weight of sodium carbonate requires for its neutralization 60 parts of pure acetic acid, 104 parts of sodium bisulfite, 45 parts of oxalic acid, 49 parts of sulfuric acid and 36 parts of hydrochloric acid. Any of these acids will dissolve metals such as zinc and give off hydrogen gas. If we should make solutions using respectively 60 grams of acetic acid, 104 grams of sodium bisulfite, 45 grams of oxalic acid, 49 grams of sulfuric acid, and 36 grams of hydrochloric acid, each in one liter of water, and were to immerse in each solution a strip of zinc, there would eventually be dissolved 65.4 grams of zinc in each acid bath and each solution would have evolved 1 gram of

hydrogen gas. It would be observed, however, that the evolution of the hydrogen gas, as evidenced by the bubbles, would be very slow in the first solution, a little faster in the second, and so on, being the most rapid in the last. The acid that reacts most slowly with the zinc, for instance, is called a weak acid and the one that reacts the most rapidly a strong acid. The strength of the various acids may be measured also by their capacity for conducting electric current. The strength of the acids will be referred to later and it is therefore appropriate that the meaning of the term be fully explained. Strength of acids, then, refers to the properties just described, while the amount of acid in a given volume of water will be referred to as the concentration. We may have a high concentration of a weak acid or a low concentration of a strong acid.

Why a Sour is Required.—A sour is required in laundry practice for a number of reasons. One is to neutralize any alkaline materials used as detergents. This is required if good work is to be expected in the laundry. For example, when goods have been bleached just a little too heavily with an oxidizing bleaching agent, a certain amount of oxycellulose is formed. If soda is present in the fabric, especially under the influence of the ironing temperature or that of storing, a colored substance is formed which more or less spoils the whiteness that is desired. Then again, sodas accelerate the tendency of starches to turn yellow under the influence of the ironing temperature. The tint of certain blues likewise is altered by the presence of sodas. Furthermore, iron compounds may sometimes be precipitated in fabrics by sodas, but may, when fresh, often be dissolved by certain dilute sours.

Another reason for using a sour is to decompose any oxidizing bleach that may be left in the goods, thus preventing any tendency for the formation of oxycellulose and the tendering of goods resulting from its formation. For this purpose, a sour that is at the same time a reducing agent, is best. Such sours are oxalic acid, lactic acid, formic acid and sodium bisulfite.

There are also a number of stains, notably those arising from certain fruit juices, as well as iron and iron ink stains, that require a treatment with a sour for their removal. If the ink is a mixture of an iron compound with an aniline ink, a second treatment with Javel water is necessary. Verdigris or copper stains often require treatment with dilute hydrochloric or sulfuric acid for their removal.

Harmful Effect of Souring.—Experiments have shown conclusively that the harmful action of sours upon cotton and linen (wool and silk withstand the action of strong sours in fairly strong solutions) depends first on the strength of the sour and second on its concentration. These findings are in harmony with the experience of this Department and with the best knowledge of physical chemistry. It appears that the harmful action of sours on the fabrics treated, is a hydrolytic phenomenon, that is, the reaction is wholly between the water and the fabric, and that the presence of the sour only hastens or catalyzes the speed of the reaction without directly taking part therein. This action has its parallel in the manufacture of glucose (corn syrup) from starch by treating the latter with acid. For this purpose, the strong acids are better, while, obviously, for laundry use the weak sours are to be recommended.

In sufficiently dilute solutions even mineral acids, such as sulfuric, nitric and hydrochloric acids, have but little

effect upon vegetable fibers. Their action however is much more severe upon cellulose than the weaker organic acids, such as acetic and formic. Oxalic acid has the strongest action upon vegetable fibers of any of the common organic acids and acetic the least. In the case of mineral acids, however, the real danger lies in the possibility of slighted rinsing. If cotton or linen fabrics are allowed to dry while containing traces of mineral acid or oxalic acid, the concentration increases until finally the fibers are attacked. This is notably true of sulfuric acid and the closely related sodium bisulfate or nitre cake.

A practical illustration of the effect of sulfuric acid solutions that are allowed to dry upon fibers at a high temperature is found in the so-called carbonizing process of wool. Carbonization consists in impregnating woolen or worsted piece goods uniformly with a dilute solution of sulfuric acid, or vitriol, as it is called in the trade, and drying in the carbonizing oven at a high temperature. The heat drives off the moisture and leaves behind sulfuric acid in a more concentrated form. The acid, as it becomes more and more concentrated, attacks any burrs that have adhered to the wool when it was on the sheep's back and have not been removed in such processes as scouring and carding. Weeds, cotton threads or any foreign materials of a vegetable nature also are changed to hydrocellulose. The pieces are then passed in rope form through machines, a pounding action being exerted upon the fibers which beats out the hydrocellulose in the form of a powder. The strength of the wool is not impaired. Raw stock is quite often carbonized, especially in the shoddy trade. Usually the best grades of woolen and worsted piece goods are carbonized either before or after dyeing, depending on the mill and the dyestuffs used. The cheaper grades of woolen piece-goods are generally dyed and then speck-dyed afterwards in a cold bath with colors

that dye vegetable matter to the exclusion of wool, the specks and burrs being darkened but not removed.

The carbonizing process indicates what may happen to cotton garments soured with a mineral acid or oxalic acid, in case the rinsing afterwards is slighted.

Sours Available on Open Chemical Market

Acetic Acid.—From the standpoint of garment conservation, acetic acid is a very desirable sour. It is the weakest of the commercial sours. It is very effective in neutralizing sodas, thereby preparing the goods for a basic or acid aniline bluing bath. In common with others, acetic acid decomposes any residual bleach. It is a better solvent for calcium and magnesium salts than any of the other available acids with the possible exception of hydrocloric acid, which it equals. It has, however, no appreciable reducing bleaching action nor any marked effect on iron stains. Most of the acetic acid left in the goods passes off with the water in the drying process. However, due to the fact that it is likely to impart a sour odor to clothes, especially if used in excess, acetic acid is not as popular as it once was.

Sodium Bisulfite.—Sodium bisulfite is an acid salt of sulfurous acid (not to be confused with sulfuric acid) which, when dissolved in water, yields some sulfurous acid, to which its souring action is due. It may be made by passing the fumes from burning sulfur or sulfur dioxide from another source, into a solution of soda ash. The sulfur dioxide may be obtained from the by-products of several industrial processes, among which may be mentioned paper-pulp manufacture by the sulfite process, certain metallurgical processes, and the manufacture of carbolic acid (phenol) and other products.

This sour, which may be had in the powdered or liquid

form, is comparable in its harmless effect with acetic acid. It is a very safe sour to use. The sulfurous acid is evaporated with water on drying and any residual substance left in the goods is mostly in the form of the normal or neutral salt. The only disadvantage attending the use of sodium bisulfite as a sour is found in its destructive effect on certain blues. This action can be largely overcome by bluing in the bath following the sour bath.

Many fruit and food stains are destroyed by the reducing action of sodium bisulfite and to some extent it can replace sodium hypochlorite as a bleaching agent. Its use for the last purpose has been found to be not as generally satisfactory as the bleaching agent commonly employed. For a general sour it has been found to be very satisfactory. Used in the proportion of six ounces with three ounces of 22° Baumé hydrochloric acid to a 3-inch bath in a 36-inch by 54-inch washer, sodium bisulfite is a safe and effective reagent for removing iron stains. This treatment affords a means of obtaining a fairly high concentration of a weak sour, sulfurous acid, which is a strong reducing agent, and renders the iron stains soluble. The hydrochloric acid does not remain in the bath as such, but reacts with the sodium bisulfite forming common salt and sulfurous acid. Sulfurous acid is not to be confused with sulfuric acid, as it has entirely different properties. The hydrochloric acid should be diluted in a gallon of water and added after the bisulfite is thoroughly dissolved.

Sodium Bisulfate.—Sodium bisulfate is obtained as a by-product in the manufacture of nitric acid from Chilian saltpeter. It has, therefore, been very plentiful, since large quantities of nitric acid are used in the manufacture of explosives. It is nearly as strong a sour as sulfuric acid, but is not quite as harmful because of the fact that any residual portion of it that may be left in

the goods is deposited upon drying in a solid form and is therefore somewhat less deleterious than sulfuric acid.

While the employment of sodium bisulfate, with certain precautions as to quantities and rinsing, has been countenanced by this Department as a souring material during periods when acetic and oxalic acids were difficult to secure, it should not be used under normal conditions. The laundryowner having the interests of the industry at heart must have due consideration for the conservation of the life of his patrons' fabrics and, therefore, will not permit the use of sodium bisulfate as a sour. Sulfuric and hydrochloric acids should never be used as sours.

Oxalic Acid.—Oxalic acid is a much stronger acid than acetic acid. Oxalic acid is manufactured from wood waste or producer gas by processes that need not be discussed in this manual. It has reducing properties toward many stains and is very effective for removing iron stains. Oxalic acid should not be used to sour colored fabrics because of its destructive action upon certain dyes. While oxalic acid is a very useful and popular sour, it is unfortunately very destructive to cotton and linen fibers when improperly used.

The curves (Fig. 3) graphically represent the difference between the effect of acetic and oxalic acids on the breaking strength of cotton cloth. The original breaking strength of the cloth that was dipped into the acetic acid solutions and dried at 80° F. was 47 lbs. It will be noticed from the curve that the sample that was dipped into the acetic acid solution of 0.5% concentration and dried without rinsing at 80° F. still has a breaking strength of 46.5 lbs., and, further, that the sample dipped in a 1% solution of acetic acid and dried at the same temperature has a breaking strength of 46 lbs. Now, since the concentration of sour as it is originally

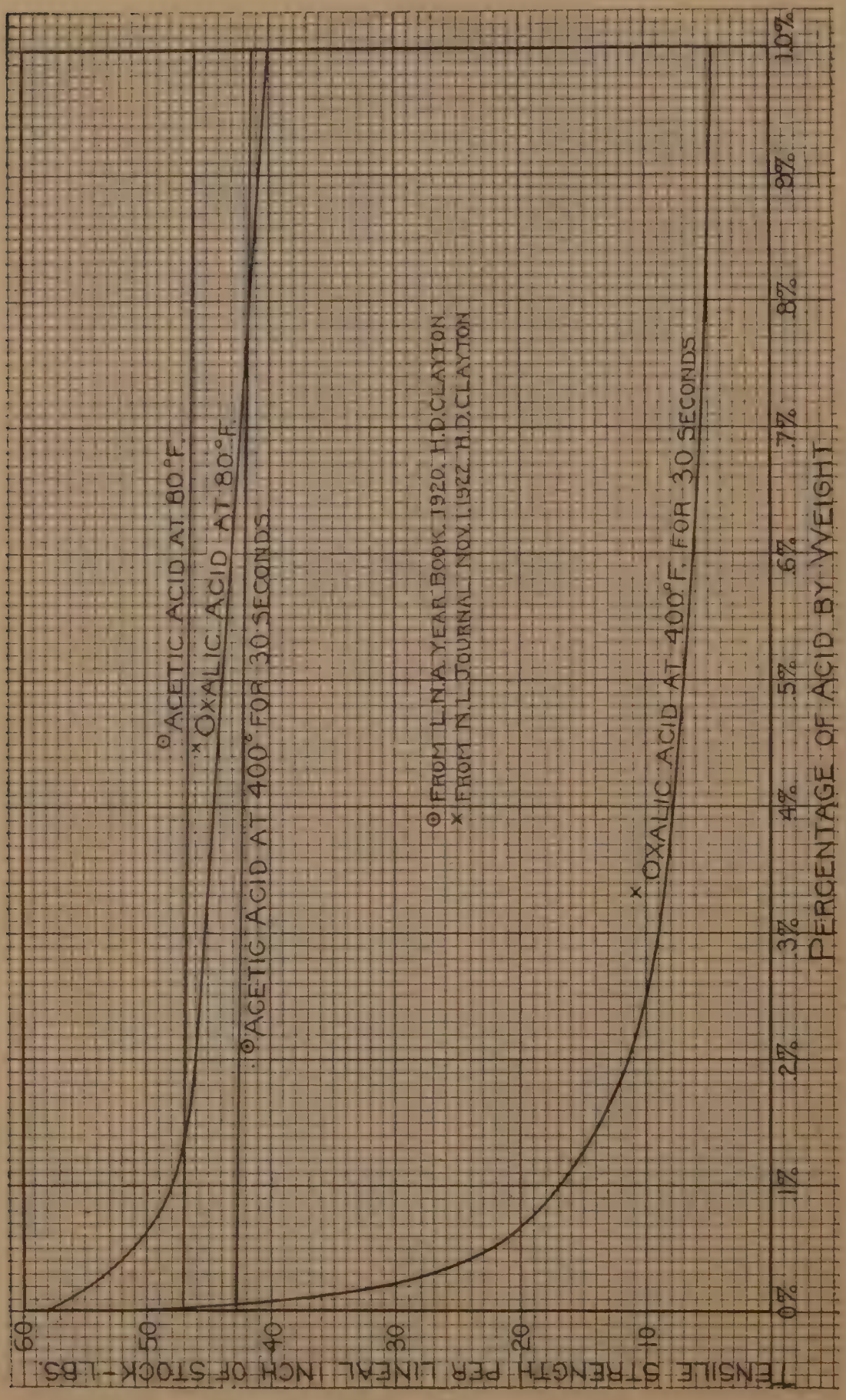


Fig. 3—Effect of Acetic and Oxalic Acids When Dried Upon Cotton

used in a laundry is only about 0.05%, it is quite evident that acetic acid is not injurious to a fabric at 80° F.

Another curve shows the action of acetic acid upon cotton cloth at 400° F. The original breaking strength of this sample was 43 lbs. Samples of cloth were immersed in the acid solutions of various concentrations and ironed dry at 400° F. In no case were the samples rinsed after immersion in the acid solutions.

The work upon which these curves are based shows conclusively that acetic acid is not injurious to a fabric at an ironing temperature of 400° F. even when not completely rinsed from the material.

The curves that graphically represent the effect of oxalic acid upon the tensile strength of cotton cloth indicate that this acid may do much damage to cotton fabrics. Samples of cloth with an original breaking strength of 60 lbs. were dipped into solutions of oxalic acid of various concentrations, as indicated by the curves. One set of samples was dried at 80° F. and the other set was ironed dry at 400° F. It will be noticed that the samples that were dipped into the 0.1% oxalic acid solution and ironed dry at 400° F. dropped in breaking strength from 60 lbs. to 17 lbs.

This Department has studied the effect of acetic acid and oxalic acid upon the breaking strength of cotton fabrics and has obtained approximately the same results as those indicated in the curves as compiled by Mr. Clayton.

It must be concluded, therefore, that acetic acid is not injurious to cotton or linen and that oxalic acid is very destructive to these fibers unless completely rinsed from the fabric before drying and ironing.

Sodium Silicofluoride (Na_2SiF_6).—Sodium silicofluo-

ride may be used as a laundry sour. It reacts with soda ash according to the following equation:

$$Na_2SiF_6 + 2\,Na_2CO_3 + 4\,H_2O \rightarrow 6\,NaF + Si(OH)_4 + 2\,H_2CO_3.$$

A small amount of silicic acid will be precipitated upon the fabrics when this sour is partially neutralized by alkalies in the wash wheel, but no ill effects due to this precipitate have been noticed. The common practice in commercial laundries is to add the sodium silicofluoride to the wash wheel in the form of a dry powder. This powdered crystalline fluoride is not very readily dissolved and unless great care is taken to have it very finely powdered, so that it will dissolve quickly, proper souring will not be realized. Better results are obtained if the powder is dissolved previous to being added to the wheel.

Sodium silicofluoride does not dissolve rust stains. It is not injurious to textile fibers, in which respect it compares very favorably with acetic acid. It imparts no odor to the clothes.

Sodium Acid Fluoride ($NaHF_2$).—Sodium acid fluoride is a crystalline substance which does not dissolve very quickly in cold or warm water. It is used as a laundry sour (patented, see page 89) and generally is applied to the wash wheel in the solid form. The crystals should be very small or finely ground so that the sour will go into solution quickly after having been put into the washer. It is advisable, however, to dissolve the acid fluoride before adding it to the wheel.

Sodium acid fluoride as a laundry sour (patented, see page 89) is a fairly good solvent for iron stains, although it is somewhat inferior to oxalic acid in this respect. It does not destroy certain stains of an organic nature that oxalic acid would destroy and likewise it does not alter the shade of dyes on colored fabrics.

Sodium acid fluoride when used as a laundry sour (patented, see page 89) is not injurious to textile fabrics. It may be said that in sodium acid fluoride are combined most of the virtues of acetic acid and oxalic acid to the exclusion of the objectionable properties of oxalic acid. There are occasional cases where oxalic acid is decidedly superior to sodium acid fluoride.

Acetic-Oxalic Acid Mixture.—A satisfactory sour for laundry purposes may be prepared as follows: Dissolve one pound of oxalic acid in one gallon of water, previously warmed to 120° F., in a stoneware or enameled container; when thoroughly dissolved and cooled, add one gallon of 56% acetic acid. For a hundred pound load of goods, use one-half pint of this mixture. This volume is equivalent to four ounces of 56% acetic acid and one-half ounce of oxalic acid.

This sour does not contain sufficient oxalic acid to remove heavy rust spots from a fabric in the course of ordinary laundry souring, but it will prevent the general yellowing of white goods that is sometimes caused by the presence of traces of iron salts dissolved in the water. A high, cold rinse should follow the use of this sour.

EXPERIMENTAL PART FOR STUDENT

1. Prepare a 1% solution in water of each of the following sours: acetic acid; oxalic acid; sulfuric acid; sodium bisulfite; sodium bisulfate; sodium silicofluoride; sodium acid fluoride. (Patented, see page 89).

2. Dip strips of cotton sheeting (1 in. by 6 in.) into each one of the solutions that have just been prepared. Allow the solution to drain from the strips and place them in an oven at 320° F. for 10 minutes. Remove the strips and compare their strength with that of the original cloth. Note results.

3. Place strips of cotton cloth that are stained with rust spots into each of the solutions prepared in (1). The temperature of the solution should be about 100° F. After 15 minutes, remove the samples and note the difference in the appearance of the rust stains.

4. Prepare 2 quarts of bluing solution, with a sour or starch-work blue, having about 10 times the concentration usually used for bluing starched collars. Divide the solution into 2 equal parts. To one part add about ten drops of 56% acetic acid. Then place a piece of bleached cotton cloth about 6 inches square into each of the bluing solutions. After about 5 minutes, remove each of the samples and notice that the soured bluing imparted the deeper color to the cloth.

QUESTIONS TO BE ANSWERED

1. Why is a sour used in the power laundry washroom?
2. What are the virtues of acetic acid for laundry souring?
3. What is the effect of oxalic acid on cotton and linen fibers?
4. When oxalic acid is used for souring, why should it be thoroughly removed by rinsing before the load is drawn from the wheel?
5. Why is a sour used in conjunction with a sour blue?

ANALYSIS OF SOURS

The sours most commonly used in the laundry industry are acetic and oxalic acids, sodium bisulfite, sodium bisulfate, sodium silicofluoride and sodium acid fluoride. (Patented, see page 89.) These compounds naturally vary considerably in strength. The equivalent strengths of the various sours may be determined by titrating equal amounts by weight of each acid or acid salt with standard normal sodium hydroxide solution. Since it is often tedious to make a detailed analysis of each acid and in order to simplify matters, the acidity of each particular sour may be calculated in terms of 56% acetic acid; that is, one pound of the sour being tested is found equivalent to a certain number of pounds of 56% acetic acid.

The apparatus required are a pair of portable scales capable of weighing grams (it is important to note that the accuracy attainable depends largely on the sensitiveness of the scales used and the care taken in weighing), a 50-c.c. burette graduated in tenths of a c.c., a burette stand, a bottle of phenolphthalein indicator, a liter measuring flask, a 100-c.c. measuring cylinder and a glass stirring rod.

Method of Procedure.—Fill the burette to the zero mark with standard normal sodium hydroxide (i.e., 40 grams of chemically pure caustic soda dissolved in one liter of distilled water). Weigh as accurately as possible 10 grams of the solution or solid to be tested and transfer it to a one-liter measuring flask. Then add distilled water until the material is dissolved and make up to one liter. Insert the

ground glass stopper and shake thoroughly. Measure 100 c.c. of this solution in the graduated cylinder, pour into a white cup and add three or four drops of phenolphthalein. Finally, begin to titrate by adding standard normal sodium hydroxide from the burette to the solution in the cup. Stir constantly with the glass rod until a faint rose color persists. Take the reading of the burette accurately to one tenth of a c.c.

Calculation:

Let X represent the reading of the burette.

Then $X \times 6$ = percentage of pure acetic acid.

$$\frac{\text{Percentage of pure acetic acid}}{56} = \text{ratio.}$$

Example: The reading of the burette is 15.8 c.c.

Then $15.8 \times 6 = 94.8\%$ pure acetic acid.

$\frac{94.8}{56} = 1.69$ the ratio value in comparison with 56% acetic acid.

That is, one pound of the sour that is being tested is equivalent to 1.69 pounds of 56% acetic acid.

For laundry purposes the use of Sodium Acid Fluoride and other Flourine Compounds having acid reactions is patented. United States Patent No. 1,016,928 of Feb. 13, 1912, owned by A. W. Wilkinson and H. B. Bishop.

CHAPTER VI

BLUES

The reason for the use of a bluing bath in the laundering of starched white-goods is so obvious that a thorough discussion of the theory involved is uncalled for. The object to be attained in the use of insoluble blue is to mask any slight yellowish color by adding a little blue, so that the resulting reflection will give the sensation of white light. In the use of soluble blues or dyes, however, the theory is somewhat more involved and a blue that is opaque to green light, that is, a blue that has more of a violet cast, must be chosen in order that the reflected light will exhibit an appearance of white. It has been found that, in a number of representative laundries, the practice has prevailed, for a long time, of not bluing flatwork (excepting table linen), and the results have been very satisfactory.

The blues that might be used for laundry purposes may be divided into two general classes, as suggested above: viz., those that are insoluble in water and those that are soluble in water.

The value of the insoluble materials depends upon the fineness and lightness of the individual particles, properties by virtue of which they may be made into a suspension in water, just as silt is suspended (not dissolved) in muddy water. If these materials are not very finely powdered or if they are excessively heavy, they will not remain evenly distributed in the water and hence will not blue evenly.

Ultramarine.—The most important blue in this class is ultramarine. It is manufactured by fusing a proper

mixture of China clay, soda ash and sulfur. The sinter produced is then ground to an impalpable powder. The naturally occurring pigment of the same chemical composition is known as Lapis Lazuli, from the name of the man who first made use of it. Ultramarine is fast to light and alkali, but is readily decomposed by relatively weak acid solutions. It is, therefore, unsuited for bluing in a sour bath, but a good quality of ultramarine is a very suitable non-sour blue. The qualities that make it a good pigment—that it, one with good covering power—render it a good laundry blue. It is very commonly used in the home laundry.

Ultramarine is comparatively cheap and can be obtained from representative paint manufacturers. To get good results in using ultramarine, certain precautions must be observed. The bluing should not be done as heavily as is commonly done in using other blues. Do not over-blue and try to rinse to color. The stock bluing should be prepared by placing three pounds of ultramarine in a bag made of double thickness of canton flannel and tying the bag securely. The cloth bag with the ultramarine in it should be suspended in a clean barrel and cold water run in until the barrel is nearly full. The bag should be agitated through the water until the color is of suitable depth. The depth of color of the stock bluing should be so adjusted that about one gallon of it will be sufficient for a standard load of flat-work. The ultramarine in one filling of the bag will be adequate to make up several barrels of bluing water. More detailed directions cannot be given here but will of necessity have to be left to the judgment of the man in charge of the washroom. *Do not drain off the bluing bath, but pull the load out of the water.* If the bluing bath is drained, cloudy work is likely to result. There is also a point of

economy in such procedure since this bluing water can be used in the first bath for the next load.

Smalt.—Another material that has been employed as a laundry blue is smalt, or, as it is sometimes called, "cobalt blue." It is a glass highly colored with cobalt and ground to an impalpable powder. Because of its high specific gravity, finer grinding is necessary for it than is required to give an equally good suspension of ultramarine in water.

Insoluble Prussian Blue.—Insoluble Prussian blue, or "Turnbull's blue," is not recommended for laundry purposes unless oxalic acid is used. In dilute solutions of oxalic acid, Turnbull's blue is soluble and may be used for a sour or non-sour blue, provided careful rinsing precedes the bluing bath in case the souring is omitted. In the trade, the term "Prussian blue" is applied to a number of compounds characterized by the presence of iron and cyanogen, and, of course, by their blue color, but differing chemically in some particulars, which will not be dwelt upon here.

Soluble Prussian Blue.—Among the soluble laundry blues available are the soluble Prussian blues and the numerous aniline blues. Of ten representative samples of bluing examined early in the work, only aniline dyes were found. Recently, several samples of the Prussian blues have been submitted. An objection to the use of any Prussian blue in laundry work has been mentioned in the literature. It was that on rewashing goods that had been blued with Prussian blue there resulted iron stains. It would seem that such a result might be looked for since Prussian blue, which is a compound of iron and cyanogen, is readily decomposed by an excessively strong soda solution, with iron oxide resulting.

However, this is a prejudice that was established when caustic soda was more generally employed than now.

During a series of tests in the laboratory plant, no ill effects were noted when rewashing goods blued with this material, even when using ten times the concentration of soda ash usually employed. Soluble Prussian blues may be successfully employed for laundry purposes, provided the use of caustic soda is avoided in subsequent laundering of the goods so treated.

Aniline Blues.—The coal-tar dyes or aniline blues are unquestionably the most suitable. This is largely true because the exact tint of the blue desired, being largely a matter of taste, varies considerably. To meet this demand, two dyes may be purchased, one a decided blue, or greenish blue, and another of a nearly violet color; by mixing the two in suitable proportions, there can be produced any cast of color from a greenish blue to a purplish blue.

This procedure also offers a means to adapt aniline blue to the use of different sours. Basic aniline blues, which represent the blues used in or following a sour bath, exhibit different tints with acid solutions of different strength. The blues that are suitable for laundry purposes are not fast to the process of washing. In fact, it is very desirable that any bluing may be washed out of a fabric with soda and water in the course of subsequent laundering. The color of some of the acid types of dye is not altered by sours or sodas, and hence dyes of this type can be used as "non-sour" blues.

Also, aniline blues have a much greater coloring power than any of the other materials that are offered for laundry bluing. For instance, one ounce of ultramarine in a given volume of water gave a depth of color on a given weight of cotton cloth equal to that given by one-fourth ounce of soluble Prussian blue and one thirty-sixth ounce of a certain sample of aniline blue. Of course, the tints are different in each case, which

makes difficult the matching of the depths of color, but when comparing colors of similar tints the matching can be done with some degree of precision.

Selection of Blue.—It would appear, therefore, that blues could be evaluated very satisfactorily by actually comparing one with another in the laundry. This, perhaps, can be done more satisfactorily in the laboratory because there smaller samples can be used with a great degree of accuracy. Then, too, various samples of cotton cloth will take up different depths of color from the same solution. Goods that are old or that have been overbleached will take up more color from a given solution than will new goods. It is desirable that the bluing test should be done on as nearly the same quality and quantity of cloth as possible. These conditions are more exactly controlled in the laboratory, where also the general classification of the blue can be made, adulterants detected, and properties noted that will assist in the evaluation.

The following requirements should be set in the selection of a bluing for laundry practice:

(1) The strength (bluing power) should be commensurate with cost.

(2) The shade of bluing should favor the faintly violet-blue rather than the green portion of the spectrum.

(3) The color should be bright.

(4) The blue should be readily and completely soluble in hot water (or hot water and acetic acid) and should not settle out of solution on standing for several days.

(5) There are few blues that are completely washed from fabrics by soap and water. It is, therefore, absolutely essential that the bluing be completely bleached out of the goods in the course of a subsequent washing. Many of the laundry blues examined left either a dull gray or a yellowish residue of color after washing and bleaching.

The washing and bleaching test was applied by bluing two square feet of muslin to a shade about ten times as heavy as that ordinarily applied in laundry bluing. The object in making a heavy bluing was to get the cumulative effect of the bluing in the course of successive trips of the goods to the laundry. During the course of washing and bleaching, the fabric should be rendered as white as a blank, unblued piece of fabric, that has been washed and bleached under the same conditions.

Because of the difficulty attached to the process of completely washing and bleaching out bluing, without leaving a yellow or a gray residue, all bluings should necessarily be made as light as good taste will allow.

CHAPTER VII

STARCHES

Starching, as practiced in the power laundry, is more of an art than a science and it is rather difficult to write informatively about such a subject. It is possible, however, in a general way to describe the differences between thick- and thin-boiling starches and to point out the properties in a starch that are desirable for laundry purposes.

Thick-Boiling Starch.—Wheat starch may be made in two ways: first, by the fermentation or "sour" process, in which all the gluten contained in the grain is destroyed; and second, by Martin's process without fermentation. In the Martin process, part of the nitrogenous matter (gluten) is recovered. Ordinary wheat flour from which the bran has been removed is used instead of the whole grain. The flour is kneaded with 40% water to form a stiff dough, which is then washed in small portions at a time in a fine sieve, while small jets of water continuously play upon the mass, carrying away the starch. By treating the partly washed starch with a solution of caustic soda (specific gravity, 1.013), the gluten is swollen and may be removed by sieving. The pasty mass of gluten left in the sieves is utilized in the manufacture of macaroni, noodles and gluten bread, but chiefly for paste, cement for leather and as a thickening material for sizing. The yield is about 55 pounds of starch and 12 pounds of gluten from 100 pounds of wheat.

One modification of this process consists in stirring wheat flour into water to form a thin "milk," which is then run into centrifugal machines. Starch, being heavier than gluten, collects next the revolving sieve. The interior layer, consisting of a mixture of starch and gluten,

is removed, washed with water and again "centriffed." Generally a great deal of starch remains in the gluten. A yield of from 40 to 45 pounds starch is secured.

Corn starch is made somewhat differently. The shelled corn is screened to remove the dirt and husks. It then passes magnets, which remove nails and bits of iron, and finally goes into wooden "steep-tanks" of 1000 to 1500 bushels capacity. Each tank has a false bottom and a circulation pipe on the outside, passing from the false bottom to near the top of the tank. Steam can be injected into the pipe to maintain the circulation and keep the steep water at about 140° F. Steeping continues for 24 hours or longer, the liquor containing about 0.3% of sulfurous acid to prevent fermentation. The liquor is drawn off and the softened grain crushed to loosen the germs.

The coarse meal formed then passes to long, narrow tanks or separators containing a starch milk of 13° to 18° Twaddle (specific gravity, 1.075 to 1.090), calcium chloride sometimes being dissolved in the liquor to increase its density. The germs float over the dam at the end of the tank, while the hulls and starchy portions sink, passing out by an opening at the bottom. The germs pass over copper screens, where they are sprinkled with water to wash out any adhering starch. The starch milk so obtained is returned to the separators.

The hulls and starchy matter are ground fine and passed over copper "shakers," some of the starch milk going back to the previously mentioned narrow tanks and the remainder passing to shakers covered with silk cloth. The chaff and husks are reground and passed through a slop machine to remove the last portion of starch.

The starch liquors are passed to agitating tanks and dilute caustic soda solution added. This dissolves some of the gluten, swells what is left, neutralizes the acid and

coagulates the fine suspended impurities. The soft doughy mass then goes to the "runs", where the starch deposits, the gluten being washed into a settling tank, from which it is pumped into a filter-press to remove the water. The "green starch" from the tables is usually mixed with water and again passed over the tables. Centrifugal machines are sometimes used for separating the starch from the wash water. Two types of machines are used. One contains an unperforated basket, the starch being thrown against the cylinder wall and packed so firmly that it remains as a thick layer, while the water collects in the middle of the drum and can be drawn off. The other type of centrifugal has a perforated basket, the water passing through and leaving the solid material deposited on the walls. Starch, being heavier, forms a layer directly on the drum wall, while inside of this is a layer of gray starch containing the impurities. It is scraped off and rewashed.

Corn contains about 54% of starch, the actual yield amounting to about 50%. Twenty-eight pounds of starch and 13 pounds of gluten suitable for cattle food is obtained from 56 pounds or one bushel of corn.

Starch, manufactured in the ways described, is known as "thick-boiling" starch; that is, when boiled with water it yields a thick, viscous "solution" which, after cooling, sets into a stiff jelly. The properties of thick-boiling starch are quite similar to those of the starch as it existed in the raw grain. There is comparatively little of this starch used in modern laundry work today.

Thin-Boiling Starch.—Thick-boiling starch may, by suitable treatment, be converted to the thin-boiling variety. Usually the treatment consists in subjecting the "green starch" to the action of very dilute sulfuric or hydrochloric acid at a temperature below the bursting point of the starch granules. This causes partial hy-

drolysis of the starch, but does not perceptibly affect the enveloping starch cellulose, the dried product being indistinguishable from the original starch, even when examined under the microscope.

Two methods of making thin-boiling starches are used. One is called the "drying in" process and consists in adding either sulfuric or hydrochloric acid in very dilute form, usually about 1% upon the weight of the green starch as taken from the tables or runs mixed with water. The excess of liquid is then drained off and the starch allowed to dry gradually at a gentle heat. The second process is called the "in suspension" method and has almost entirely replaced the former. It consists in dumping the green starch into a tank of warm water, the temperature of which is below the bursting point of the granules. This water contains 0.1 to 0.2% of acid, the starch being kept in suspension by means of agitators. When the process is complete, the starch is drained and then dried in the usual manner. The extent to which the starch is "thinned" is proportional to the concentration of the acid used, the temperature at which the operation is carried out, and the duration of the treatment.

It is possible to alter the characteristics of "green starch" by other means than the acid treatment, although the latter is more commonly used. It may be stated here that whenever mineral acid is used in the treatment of starch it should be neutralized before the starch is used in the laundry. The reason for this requirement is that mineral acids are known to be very injurious to cotton and linen fabrics. Only a very few samples of starch containing mineral acid have been noticed and it is unlikely that much acid starch finds its way into laundries. However, as a safeguard against the possible use of such starches, about one ounce of borax may be added to a kettle or batch of starch at the time of boiling. The

borax will neutralize any acid present and will cause the starch solution to become slightly alkaline.

It will be remembered that the function of the borax is to neutralize any traces of mineral acid that may be in the starch. After this has been accomplished, the borax itself should be neutralized with acetic acid.

There is a good reason for not using an alkaline starch solution, especially for starching collars. Collars are usually blued with a sour (basic) blue, and unless they are strongly soured in the wheel, the final condition of the collar may be alkaline if an alkaline starch is applied later. Should the collar actually be made alkaline by the starch solution, it follows that the blue will either entirely disappear or possibly turn yellow during the passage of the collar through the dry-room.

Even though no borax or alkali has been added to the starch, thereby rendering it alkaline, nevertheless, it may be possible that the starch solution is alkaline because of the use of a slightly alkaline water in the preparation of the starch. Some raw water is naturally alkaline, while, furthermore, a water that runs high in temporary hardness will become slightly alkaline when softened by a zeolite softener.

Regardless of the effect of alkaline starch on sour blues, there may be "yellow collars" from the dry-room, provided that the water contains an appreciable amount of iron, which, when present, is converted to the reddish brown hydrate in alkaline solution.

The following procedure is recommended for the preparation of starch solution:

Assume that a batch of 40 gallons of starch is to be prepared containing 9 to 11 ounces of starch to the gallon. Weigh out the desired amount of starch and place it in a container, in which it may be treated with sufficient water to work the mixture, first into a thick paste and then, by the addition of more water, into a very thin

paste. This thin paste should then be strained through cheese cloth or through a fine mesh screen to remove any large lumps of starch or coarse foreign matter. To the strained starch paste, add sufficient water to bring the volume to about two-thirds of the desired final volume. To this starch-water mixture, add about one ounce of borax and proceed to boil the solution. Continue to boil in the usual manner. When the boiling is completed, add one-half pint of 56% acetic acid and continue to stir until the solution is cooled to room temperature. Make up the solution to the desired volume with cold water. The acetic acid has no thinning effect on the starch solution and it does neutralize any possible alkalinity. When acetic acid is added to starch as prescribed, the collars must be blued only very lightly in the wheel or the finished collar will be too blue because the acetic acid in the starch helps to bring out the full effect of the blue.

How Thin-Boiling Should a Starch Be Made?—There is no universally accepted laboratory method for testing the viscosity of starches, each manufacturer adhering to his own scheme for determining this value. It is unfortunate that such is the case for the reason that each starchmaker must refer to the viscosity of his starch in terms that only he understands. If there were an accepted standard method for determining viscosity, this particular property of starches might be expressed in terms that would be readily understood by everyone.

It is possible, however, to discuss this subject in terms that are readily understood by the practical user of starches in the laundry. A starch should be thin-boiling to the extent that when a "solution," containing from 9 ounces to 11 ounces of starch to the gallon of water, is cooled after boiling it will remain in a perfectly fluid condition. It is desirable that the cold starch solution be fluid, especially when collar starching is applied cold. If the starch solution is too viscous or thick, the starch

will not penetrate thoroughly the voids of the fabric. Furthermore, a too viscous starch requires an undue amount of rubbing in order to work it into the fabric of the collar. If the starch solution is full of gelatinous lumps, "high-lights" will appear on the ironed collar. Of course a starch must not be so thin-boiling that its solution will have an insufficient stiffening effect on the fabric.

Not all of the so-called thin-boiling starches on the market are equally good for collar starching. Certain products are too thick-boiling for convenient use in cold starching.

Wheat Versus Corn-Starch.—When comparing one starch with another, quality is the factor that must be considered. Quality is a relative term referring to a number of characteristics, such as uniformity, adhesiveness or strength, color, pliability or elasticity, smoothness, penetration and purity. It should be borne in mind when making a comparison of the various starches—wheat with wheat, corn with corn, or corn with wheat—that it is necessary to compare those of similar viscosity at the same temperature and strength and prepared in the same way. We are all familiar with one wheat starch, for example, giving a thick viscous solution when cold, while another wheat starch is much thinner when prepared under similar conditions. The same is often true of corn starches as well. Such results are simply due to the fact that one starch received further acid treatment than the other, consequently becoming more thin-boiling. The starching qualities of a starch depend entirely upon the starch itself.

It may be said, however, that a thin-boiling corn starch is preferable to a thick-boiling wheat starch, and vice versa. The merits depend largely on the method of preparation for the market. Each laundryowner has a particular standard of quality which gives satisfaction in

the community served. It is a generally accepted fact, however, that corn starch will cause a collar to be somewhat less pliable and more brittle than a collar starched with the same amount of wheat starch. Wheat starch imparts more "body" to the collar, accompanied by a flexibility that is not attained with corn starch.

Ordinarily, collars starched with corn or wheat starch will take up about 10% of their weight of starch. A blended starch consisting of equal parts of wheat and corn or of one part wheat to two parts of corn starch makes a very good product for laundry starching.

References: Thorpe's "Dictionary of Applied Chemistry;" "Maize Products, and Maize Starch and Its Products," W. P. Kaufman, *Journal of the Society of Chemical Industry*, May 16, 1910.

CHAPTER VIII

EFFECT OF HIGH TEMPERATURES ON COTTON CLOTH

It is well known that the high temperatures of ironing machines are very destructive to the cotton padding and the cloth coverings of presses and flat-work ironers.

There is a practice in many laundries of increasing the production of ironing machines by operating them under steam pressures corresponding to temperatures dangerously near or above the decomposition point of cotton cloth. Before this change is made it is well to consider that there is a limit to the temperature at which cotton cloth may be heated without permanently injurious effects. The limiting temperature varies with the fabric. Some cotton fabrics begin to weaken in breaking strength when ironed at about 300° F., while others are not affected much below 350° F.

Unbleached cotton cloth will withstand a slightly higher temperature than the bleached cloth. For example, if an unbleached sample of cloth were to decrease in breaking strength at 350° F., the same material bleached would begin to weaken at about 300° F.[1] This falling off in breaking strength of cotton cloth is due to an "invisible scorch," which permanently injures the cloth thus affected. The scorch does not become apparent to the eye until a temperature is reached that is from 50° F. to 100° F. higher than that at which the cloth begins to suffer a weakening effect from the temperature.

How close, then, to the scorching temperature of cotton fiber does the steam heat the ironing surface of the machine?

[1]See address by H. D. Clayton, *L. N. A. Year Book*, **1920**, page 224.

Saturated steam at a pressure of 90 lbs. per sq. inch is at a temperature of 320° F.

Saturated steam at a pressure of 100 lbs. per sq. inch is at a temperature of 327° F.

At 110 lbs. pressure per sq. inch, saturated steam is at a temperature of 334° F.

It is evident that the temperature of an ironing machine operated at 90 lbs. steam pressure is about that at which cotton cloth beings to deteriorate, although this deterioration is not at once evident as a scorch. In fact, there is no immediate evidence of scorch on the padding and covering of a machine that is operated at 110 lbs. pressure. The element of time enters into the effect of temperature on cotton fiber, as is demonstrated by the manner in which the coverings of ironing machines develop a more pronounced scorch on each succeeding day they are used.

If it were not for a cooling effect that is due to the evaporation of water from the fabrics that are being ironed, the padding and coverings would deteriorate more rapidly than they actually do.

Maximum Temperature at Which an Ironing Machine Should be Operated.—The correct temperature at which to operate an ironing machine is a subject that must be considered from a practical point of view, for the reason that a flat-work ironer must be used to iron both heavy and light-weight goods, such as bed spreads and sheeting. A sheet may be ironed dry by one pass through the machine, while, under the same conditions, a spread may require two or three passes before it is ironed dry. Obviously, it would be a great convenience to be able to iron the spread dry by one pass through the machine; but to do so would require either a larger ironing surface than is provided in the present day machine, or the alternative of operating the existing machines at a higher temperature than that commonly employed.

It is quite evident that a machine that would iron a

heavy spread on one pass would dry a thin sheet long before it had passed through the ironer, thus exposing the dry sheet to the action of the high temperature for the remainder of the time. Furthermore, the action of temperature is most pronounced on dry cotton cloth.

The conclusion must follow that, since the temperature of 334° F., possessed by a pressure of steam at 110 lbs. per square inch, is already above the point at which bleached cotton fabrics are unfavorably affected, it would be unwise to operate an ironing machine at a higher temperature. It also follows that an ironer that is used only for heavy articles, such as spreads, might be operated at a much higher temperature than 334° F. without injury to the fabric, provided that the speed of the machine was so timed as to deliver the spread in an ironed condition at the point where the moisture has been just sufficiently removed for good ironing. The high temperature of the ironing machine would thus not act upon the dry fabric for sufficient time to injure it, although the life of this padding would suffer.

Temperature at Which to Operate Presses.—Both heavy and light-weight garments made of cotton, wool or silk are ironed on presses. The press operator is able to determine the length of time that is necessary to dry any particular fabric. However, it would be unwise to operate presses at a temperature higher than that which is known to be injurious to a dry fabric exposed to it for a few minutes only.

Effect of High Temperatures Upon Wool and Silk as Compared With Cotton.—Tests were conducted in the laboratory to determine the comparative effect of high temperatures on cotton, wool and silk fabrics at temperatures of 231° F. and 329° F., respectively.

The dry samples were placed in an oven at 231° F., and after heating for 15 minutes the white silk fabric began to acquire a pale yellow color. The wool and

cotton cloth were unaffected. This is an indication that silk fabrics must be dried very carefully or they will be discolored at the temperature of drying or ironing. When silk fabrics are dried in a dry-room, the temperature should not be above 212° F. and the fabric should be removed as soon as it is dry.

When silk garments are dried and ironed on a press, the steam pressure should not be above 90 lbs. per sq. inch and the operator must be careful to remove the fabric from the press as soon as possible after it is dry. When silk fabrics are ironed by hand, care must also be exercised by the ironer, if yellowing of the fabric is to be avoided, although obviously the hand ironer is at once able to detect any yellowing or light scorch that may appear.

Effect of Continuous Ironing on Fabrics.[1]—A series of tests were performed that consisted in heating samples of the same fabrics in the dry air of an oven and on a flat-work ironer, respectively.

The samples on the flat-work ironer, heated by steam at a pressure of 100 lbs. per sq. inch, were exposed to moist hot air during the 46½ hours that the machine was operated. This part of the test was conducted in a power laundry. The samples were placed under the flap of the outer roll of covering.

The figures in the table on page 108 show that the samples of wool (on the flat-work ironer) suffered greater deterioration in strength, as determined by the Mullen and the grab tests than those heated in the oven. However, the woolen cloth heated in the oven showed some shrinkage in the warp threads, while no shrinkage took place in the pieces heated on the flat-work ironer. This shrinkage probably accounts for the better showing made in these tests by the samples heated in the oven. Taking

[1]*L. N. A. Bulletin*, October and November, 1923.

WOOL

	Mullen		Grab Test, Breaking Strength			
	Number	Loss	Warp	Loss	Filling	Loss
Original sample	100.0	.....	36.75	.....	18.5	.....
46½ hours on flat work ironer	80.0	.....	33.33	.....	15.0	.....
Total loss	.....	20 %	.....	9.3 %	.....	19 %
Loss per hour	.....	0.43%	.....	0.2 %	.....	0.41%
18 hrs. of dry heat at 165°C	86.0	.....	34.5	.....	19.5	.....
Total loss	.....	14 %	.....	6.1 %	.....	.....
Loss per hour	.....	0.8 %	.....	0.34%	.....	.....

COTTON

	Mullen		Grab Test, Breaking Strength			
	Number	Loss	Warp	Loss	Filling	Loss
Original sample	135.5	.....	54.2	.....	49.0	.....
46½ hours on flat work ironer	100.0	.....	36.66	.....	35.0	.....
Total loss	.....	26 %	.....	32 %	.....	30 %
Loss per hour	.....	0.56%	.....	0.7 %	.....	.64%
18 hrs. of dry heat at 165° C	97.0	.....	33.0	.....	29.5	.....
Total loss	.....	28 %	.....	39 %	.....	40 %
Loss per hour	.....	1.55%	.....	2.1 %	.....	2.2 %

SILK

	Mullen		Grab Test, Breaking Strength			
	Number	Loss	Warp	Loss	Filling	Loss
Original sample	90.0	.....	30.0	.....	28.25	.....
46½ hours on flat work ironer	65	.....	11	.....	16	.....
Total loss	.....	27.7 %	.....	63 %	.....	43 %
Loss per hour	.....	0.6 %	.....	1.3 %	.....	0.93%
18 hrs. of dry heat at 165° C	59.5	.....	14.0	.....	16.75	.....
Total loss	.....	33.9 %	.....	53 %	.....	40 %
Loss per hour	.....	1.8 %	.....	2.9 %	.....	2.2 %

Table I—Showing Action of Heat Upon Textiles

the results as a whole, it is evident that both in the oven and on the flat-work ironer, the woolen cloth was the least affected as to strength, although it showed greater discoloration (yellowing) than either the cotton or silk.

The superiority of wool over cotton in withstanding high temperatures is not sufficient to warrant its use in preference to cotton for roll coverings, because the price of woolen cloth is much the higher.

CHAPTER IX

CORROSION *

By the term "corrosion," or rusting, as applied to hot-water systems, is meant the destruction of metal pipes and tanks by water or by some ingredient dissolved in the water. Much confusion is occasioned by the free interchanging of the terms "scale" and "corrosion," and it is desirable to point out the fact that by "scale" is meant a deposit on the surface of the pipe or tank of some substance carried in solution by the water, while the term "corrosion" applies to the actual solution and disintegration of the metal itself. It is the latter process with which this chapter will be more particularly concerned. The term "rusting" is very frequently and quite correctly substituted for "corrosion."

It is a well known fact that more trouble is experienced by some laundry owners than by others, even though they are using the same city water-supply. Furthermore the water-supply of one city may be much more corrosive than that of another. In order to explain these statements, it will be enlightening at this point to discuss briefly some of the more important factors that influence the corrosion of metal pipes. Since the use of steel and of iron pipe is much more general than that of other metals for hot-water systems, most of the following remarks will be confined to the corrosion of iron and steel.

The factor that is quite generally considered of primary importance in the corrosion of steel pipe, is the dissolved oxygen (or air) contained in the water. Without going into a theoretical discussion of the exact rôle

*By C. R. Texter, Mellon Institute of Industrial Research.

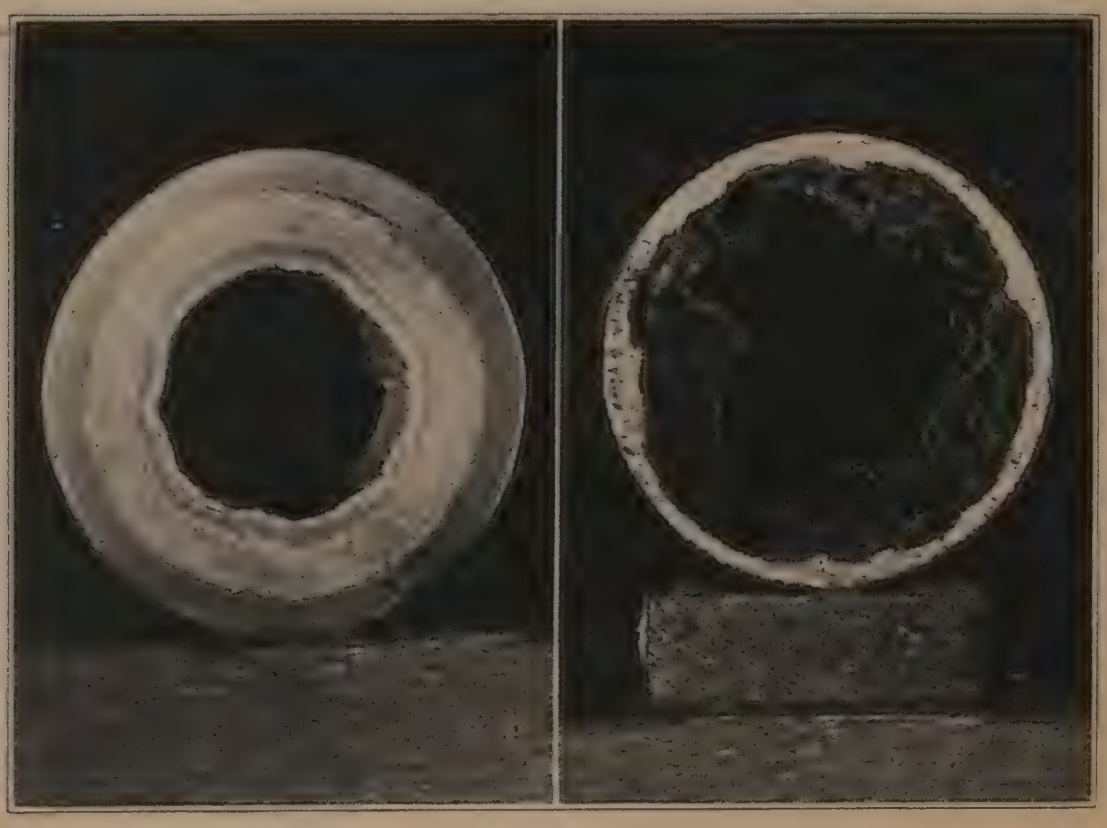
that oxygen plays in the phenomenon of corrosion, it may be said that it has been very conclusively proved that iron or steel will not "rust" in ordinary water from which the oxygen has been removed.

A second important factor influencing corrosion is the temperature of the water. As in practically all chemical reactions, the rate of corrosion of iron and steel in water is accelerated by an increase in temperature.

The velocity of flow of the water through the pipes is another factor that affects the rate of corrosion under some conditions. This factor is not so important as those of oxygen and temperature, but it has been shown that in general the rate of corrosion becomes greater as the velocity is increased. The probable cause is a combined effect of accelerated corrosion and mechanical erosion. The erosion is due to a wearing away of the walls of the pipe by suspended solid particles in the water.

Another very important factor that influences the corrosiveness of water in hot-water systems, is the composition of the water itself. Without going into detail upon this phase of the question, a general statement can be made that covers most conditions. "The softer the water the greater will be its corrosiveness, and the harder the water the less the corrosion." For instance, in New York City, where the water is very soft, steel and iron pipes in hot-water supply systems last only a few years, while in the cities using water from the Great Lakes the same pipes may be used under the same conditions from three to five times as long. The explanation of this fact is that the Great Lakes water is high in calcium bicarbonate, which is thrown out in the heaters and hot-water supply lines as hard scale of calcium carbonate (limestone). This scale protects the underlying metal.

These two sets of conditions are shown in Figure 4. "A" is a pipe which carried hard water for about 10 years and is about half-filled with a very hard scale, while the



A FIG. 4 B

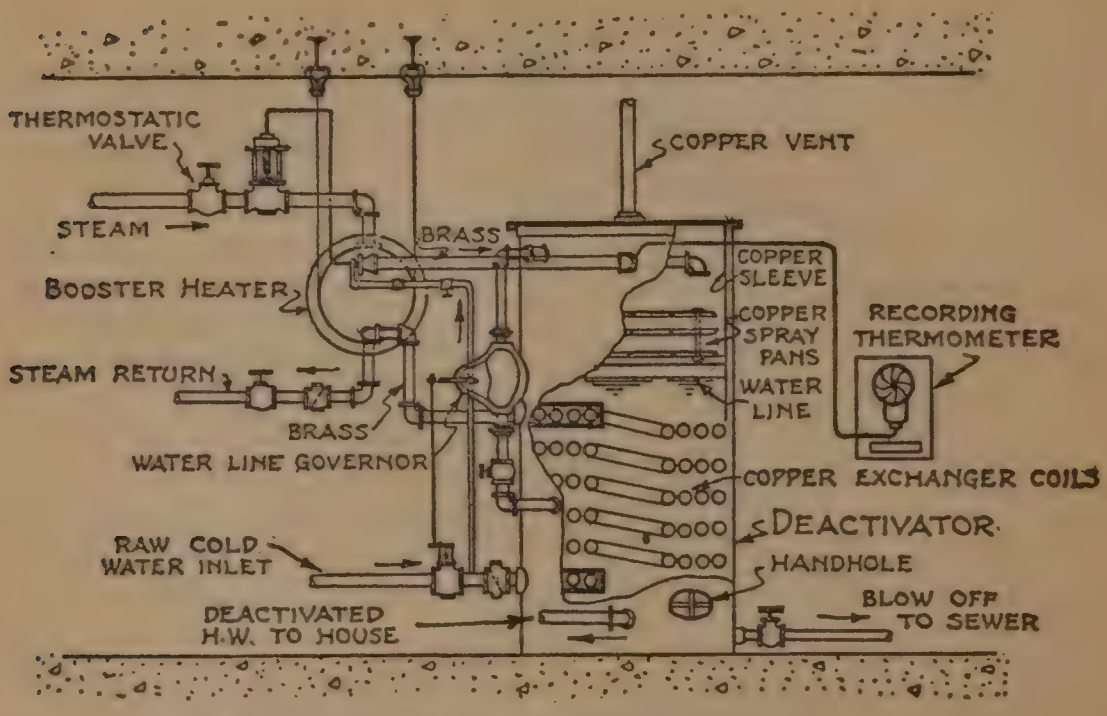
underlying metal is uninjured. "B" is the same kind of pipe, which was in service only about 5 years, but carried soft water. It is very badly pitted and partly filled with a porous mass of red rust, which offers no protection to the pipe.

The question of hard and soft waters is of considerable interest to laundry operators, because of the increasing use of various water-softening devices as a means of soap conservation. There seems to be little doubt that the saving in soap due to softening the water supply is partly counteracted by increased expenses in the way of heater and pipe-line replacements. Just where the happy medium occurs it is impossible to state, but the fact seems to be generally agreed upon by laundryowners that "zero water," or at least water with very little hardness, is an essential condition in successful laundry operation. Therefore, it becomes necessary to solve the corrosion problem as it occurs in very soft waters.

Prevention of Corrosion.—After becoming familiar with some of the more important factors influencing corrosion, the question of prevention may be approached more logically. There seem to be but two primary avenues of attack. The water itself may be rendered less corrosive, or the pipe may be made more resistant to corrosion by changing its composition, or by the application of some protective coating. It is found that the presence of dissolved oxygen in the water, provided that the water is not acid, is absolutely necessary for the continuation of corrosion, at least in iron and steel pipe, and probably in the case of the non-ferrous metals also. Recognizing, therefore, the important bearing upon corrosion of the presence of dissolved oxygen in natural waters, the question resolves itself primarily into one of oxygen removal or deaeration.

Generally speaking, there are three methods used to accomplish this end. One procedure is to remove the oxygen chemically, by adding to the water some compound that is readily oxidized, such as sodium sulfite or ferrous hydroxide. This process has not met with much favor, because of the difficulty of applying the chemical in the proper proportions, and also because of the objectionable feature of having to filter off the resulting precipitate before the water is fit for domestic purposes.

Mechanical Deaeration.—The second method, the one that is coming into wide practical use, is to deaerate the water mechanically. This is accomplished in two ways. One is to heat the water in a specially constructed apparatus, to a point just below the boiling-point, a temperature at which the solubility of gases in water is almost zero, and then to cause this heated water to spill down at atmospheric pressure over a series of shallow pans, thus allowing the oxygen to be liberated and exhausted through a vent in the top of the tank. In order



DE-AERATING DEACTIVATOR
TYPE F-3

FIG. 5

to provide water at the proper temperature for domestic use, a heat exchanger is located in the lower section of the apparatus, where the incoming cold water is partially heated and the temperature of the supply water reduced to about 150° F. A diagram of the apparatus is shown in Figure 5. This process works on the same principle as an open heater, but has the advantage of spreading the heated water out into thin sheets and giving the gases every opportunity of escaping.

The other way of mechanically deaerating water is somewhat the same as that just described, with the exception that the water is not heated to such a high temperature and a vacuum is employed. Substantially, the process is to heat the water to a predetermined temperature below its boiling-point and then to admit it suddenly into an evacuated chamber, the degree of vacuum being predetermined in consideration of the water being admitted. The water entering this evacuated chamber, be-

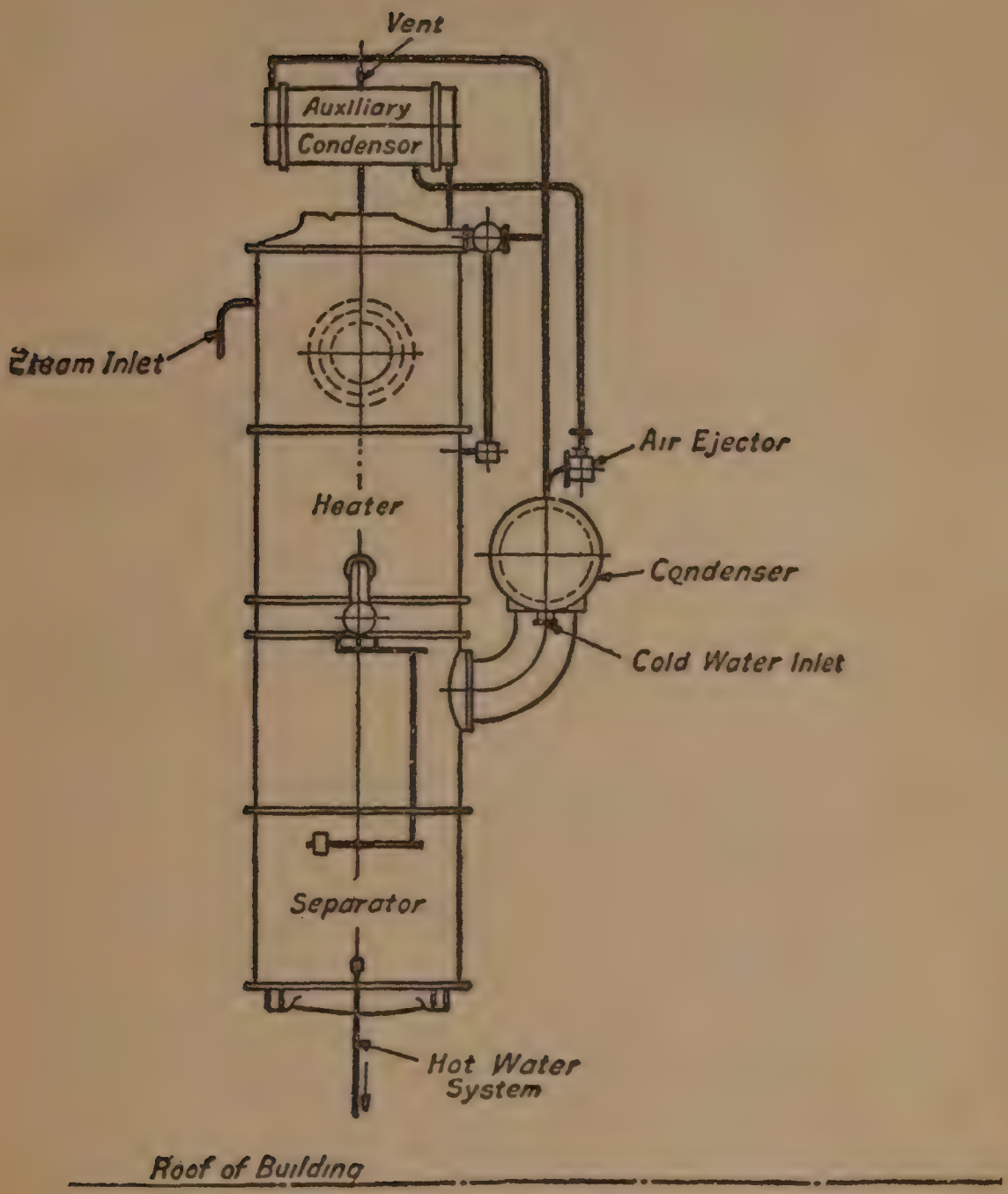


FIG. 6—DEAERATOR OPERATING AT REDUCED PRESSURE

ing super-heated, immediately flashes into vapor, thus liberating the oxygen as well as all other gases. The water vapor and gases then pass into the condenser, where the vapor is condensed by cold water going to the heater and the non-condensable gases are drawn off by means of a pump. This type of apparatus—as shown in Figure 6,—is capable of reducing the oxygen to 0.2 c.c. per liter or

less. Water carrying such a low oxygen concentration is very desirable for use in boilers equipped with steel economizer tubes.

"Deactivation" By Means of Steel Scrap.—The third method of deoxidizing water for use in hot-water supply systems, is one that has been called "deactivation." In brief, the method consists in removing the oxygen by means of a storage tank filled with easily corrodible scrap iron or steel in suitable form, such as steel lathing. The water is heated in an ordinary hot-water heater to about 160° F., and then allowed to circulate through the tank containing scrap iron, to which the water gives up its oxygen, thereby expending its corrosive energy. In other words, the water does all its rusting in one place and comes out of the "deactivator" incapable of causing further corrosion in the pipe lines. The water, before being used in the system, sometimes, and especially when it is destined for domestic use, must be filtered in order to remove suspended or colloidal iron. One type of deactivator is shown in Figure 7.

The size of the deactivating tank depends upon the temperature of the water, but for the average system (about 160° F.), it may be stated roughly that the tank must be large enough to provide storage capacity for one hour's supply of water. By this process it has been found that the oxygen content of the water is reduced from an average of 7 c.c. per liter to less than 0.5 c.c. per liter. Long period tests have shown that if the oxygen concentration in a hot-water supply system is kept below this point, the life of steel or iron pipe will be increased about ten times over that of pipe carrying water saturated with oxygen. For excessive temperatures such as are found in steam boilers and boiler economizers, the oxygen concentration must be kept down to a point somewhat below 0.2 c.c. per liter in order to give satisfactory protection to the tubes. The best practice is to use water carrying

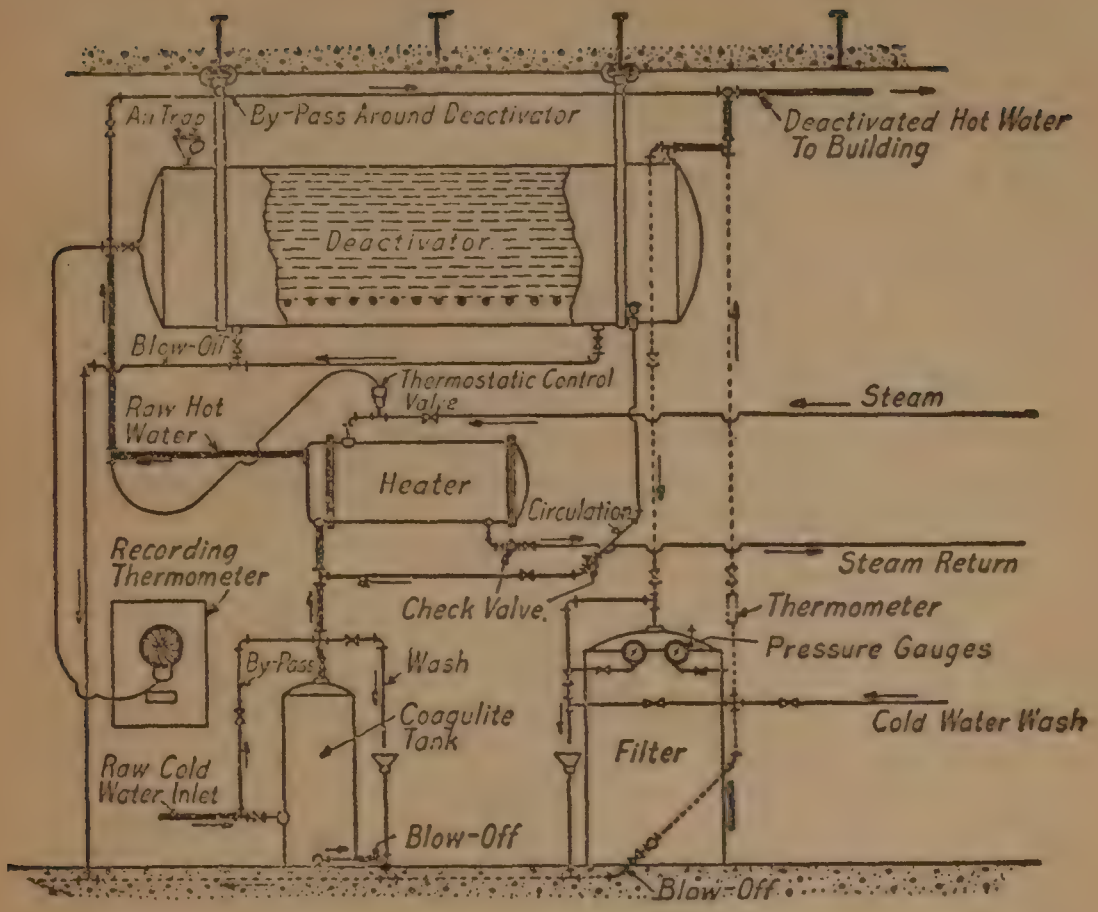


FIG. 7—HOT WATER DEACTIVATOR

absolutely no dissolved gases as delivered by the vacuum-type deaerator briefly described above.

Protective Coatings.—The other method of preventing corrosion of the internal surface of steel pipes carrying hot water, namely, by the application of protective coatings, may be considered as including metallic and non-metallic coatings.

Among the metallic coatings applied to water pipe are zinc and aluminum. The chief non-metallic coatings are cements and a variety of asphalt and coal-tar preparations. These all have their special adaptations and uses and much could be written about each one of them, but space will not permit of their consideration here. Suffice it to say that they must be applied to the pipe before

it is put into service, and, therefore, once the water has eaten through the protective material, there is no chance for its renewal and the bare steel is exposed to the destructive action of water. This shortcoming of most artificial coatings suggested the desirability of a protective coating that could be applied continuously or intermittently after the pipe had been put into service in the hot-water supply system.

"Self-Healing" Protective Coating.—With this object in mind, a particular line of investigation was started several years ago in the research department of the National Tube Company, in an effort to find some material which, when added to the heater, would be carried throughout the hot-water supply system and be precipitated out upon the internal walls of the iron or steel pipe in the form of a "self-healing" protective film. The preliminary research indicated that soluble silicates were well adapted to this purpose, and after numerous tests it was found that a certain form of fused silicate of soda most nearly met the requirements.

In order to facilitate the development of this so-called "silicate process" and to determine the best way of applying it, an Industrial Fellowship was established at Mellon Institute of Industrial Research of the University of Pittsburgh and the work continued there. The value of silicate of soda lies in the fact that it is readily carried in solution by the hot water throughout the system, and is precipitated by combining with colloidal iron or soluble salts in the water, in the form of an impervious film that prevents the corrosive water from coming into actual contact with the metal. One very important advantage of this process is that the treatment may be made continuous or intermittent as it is found necessary, the color of the water being a very good indication as to just how to control the operation.

The question might be raised as to the particular ad-

vantage silicate of soda has over any other alkali, such as lime or caustic soda, in preventing corrosion. The reason for using the silicate is that, whereas any alkali has a tendency to build up a protective coating in pipes carrying hot water, it has been found that the film formed by silicate of soda is more adherent and less pervious than any other quickly deposited scale. It is also very permanent. This last statement has been well substantiated in the practical application of the treatment in Mellon Institute hot-water lines. At this place the silicate has been entirely cut off for periods of two or three consecutive weeks, during which time the water continued to run bright and clear at all times.

The "silicate process" has been in practical use for over two years in Pittsburgh and for somewhat over a year in New York and Boston, and it has been demonstrated that the color of the water at the faucets has been changed from a yellowish red or even dark brown at times to absolute clearness in about a week's time. Furthermore, weighed test pieces show that actual corrosion is reduced to one-half or less. The treatment is applicable to old rusty hot-water heaters and almost worn out pipe lines, as well as to new installations, and is therefore found to be very advantageous for small apartments or dwellings where the "red water plague" is almost a nightmare to the inhabitants and for laundries where considerable losses are experienced on account of rust staining the clothes.

It must be borne in mind, however, that the "silicate process" is only applicable to small buildings where the length of piping in the hot-water supply system is relatively short and not to large buildings. Where the lines are of considerable length, it has been found that the protective constituent spends itself and is deposited in the part of the system near the heater, and, in consequence, corrosion proceeds apace in remote lines due to the main-

tenance of a high oxygen content. Therefore, in large buildings, it is recommended that one of the systems of deoxidation be installed, because, as has been said before, no protective-coating method is as efficient as deoxidizing the water and thereby removing the real cause.

The question has been raised as to the value of silicate of soda in preventing corrosion in a water that has been reduced to "zero hardness." An attempt has been made in one of the large laundries in Pittsburgh to decide this point, but it has not yet been possible to arrive at definite conclusions. The arrangement of the system and the great amount of water consumed have made it difficult to maintain sufficient silicate in the water for a satisfactory period of time. Nevertheless, the operators of the laundry report a continuous supply of water free from any traces of red rust, which was not the case previous to the installation of the equipment for effecting the treatment with silicate. Rust-free water alone is an important enough factor to justify the use of some protective material such as silicate of soda.

The results of a short period test with silicate-treated water is shown in Figure 8.

This figure, when compared with Figure 9, shows the difference between Pittsburgh city water with and without the silicate treatment. The test lasted for two months, but even in this short time the development of corrosion pits is very evident where the treatment was not used, while the pipe carrying the silicate water is quite free from pits. The fact is emphasized, in this connection, that Pittsburgh water carries from 5 to 10 grains of hardness. In the above tests, the amount of silicate added to the water was controlled by phenolphthalein tests from time to time. An average alkalinity to phenolphthalein of 10 parts per million was maintained.

A perfect method of mechanically applying silicate of

Black Galvanized

FIG 8—WITH SILICATE TREATMENT

soda to hot-water systems has not yet been placed on the market, but the process offers very promising possibilities and can well be considered by laundryowners and managers.

Black Galvanized

FIG. 9—WITHOUT SILICATE TREATMENT

CHAPTER X

HEAT INSULATION*

The function of a heat-insulating material is to retard heat-flow. It is not possible to prevent completely, by means of insulation, the flow of heat, because all substances conduct heat to some extent. However, by the use of a good heat-insulating material, it is possible to prevent a very high percentage of the flow of heat that would otherwise take place from a bare or insulated surface.

It is recognized generally that the losses from bare pipes and boilers are considerable, but the real magnitude of these losses is little appreciated. The fact that the loss from 1000 lineal feet of 3 in. bare pipe at the temperature of saturated steam at a pressure of 120 lbs. per sq. inch represents 385 tons of coal annually, is a sufficient justification for the serious consideration of the subject.

Tables II and III show the actual heat losses that occur from horizontal, bare iron steam-pipes at various temperatures and steam-pressures.

The units of heat-loss used in these tables is the British thermal unit, which is the amount of heat-energy required to raise the temperature of 1 lb. of water through 1 degree Fahrenheit. A good grade of coal furnishes 13,000 to 14,000 B.t.u. per lb. and the heat-loss in pounds of coal for any condition not shown in Table I can, therefore, be readily calculated from Table II and the heat-content of the coal.

The actual losses from steam-pipes, when insulated, will depend, of course, upon the conductivity of the material with which they are insulated, the thickness of the

*By R. H. Heilman, Mellon Institute of Industrial Research.

Gage Press.	Hot Water			10 Lbs.			80 Lbs.			120 Lbs.			160 Lbs.			200 Lbs.			200 Lbs and 100° F. Superheat.			275 Lbs. and 250° F. Superheat.		
Temp.	180° F			239.4° F.			324.0° F.			350.0° F.			370.7° F			387.9° F.			487.9° F			664.3° F.		
Pipe Size	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B.t.u. per Lineal Ft. per °F. Diff. per Hr.
½"	1.32	526	.605	2.24	897	.670	3.92	1566	.779	4.51	1805	.815	5.25	2010	.846	5.53	2210	.875	8.60	3440	1.040	16.15	6460	1.375
1"	1.91	763	.878	3.26	1305	.973	5.72	2290	1.138	6.50	2601	1.178	7.27	2910	1.242	8.07	3230	1.280	12.56	5026	1.520	23.84	9540	2.030
1½"	2.65	1060	1.220	4.54	1818	1.357	7.98	3190	1.586	9.28	3710	1.676	10.42	4165	1.751	11.36	4550	1.804	17.94	7175	2.170	33.76	13500	2.870
2"	3.24	1297	1.491	5.36	2142	1.600	9.78	3910	1.943	11.37	4549	2.052	12.75	5100	2.145	14.00	5600	2.220	22.10	8825	2.670	42.20	16890	3.590
2½"	3.86	1545	1.778	6.65	2660	1.984	11.66	4660	2.320	13.66	5460	2.464	15.25	6100	2.564	16.70	6690	2.650	26.64	10650	3.220	50.50	20200	4.300
3"	4.56	1824	2.100	8.24	3292	2.460	13.88	5550	2.760	16.14	6450	2.910	18.04	7210	3.030	19.84	7945	3.150	31.60	12640	3.820	58.25	24300	5.170
3½"	5.18	2070	2.380	8.89	3554	2.655	15.82	6325	3.145	18.31	7322	3.305	20.50	8200	3.450	22.60	9040	3.580	35.90	14360	4.345	69.00	27600	5.860
4"	5.78	2305	2.650	9.87	3950	2.950	17.70	7075	3.520	20.50	8200	3.700	22.85	9145	3.842	25.15	10060	3.981	40.10	16040	4.850	72.40	30920	6.560
4½"	6.35	2540	2.920	10.94	4370	3.260	19.48	7790	3.878	22.60	9025	4.075	25.30	10120	4.250	27.75	11100	4.400	44.05	17620	5.326	85.60	34240	7.286
5"	6.95	2780	3.200	11.97	4790	3.575	21.25	8500	4.232	24.62	9850	4.450	27.60	11050	4.650	30.40	12140	4.805	49.35	19740	5.960	94.50	37800	8.050
6"	8.20	3280	3.775	14.21	5680	4.240	25.30	10110	5.024	29.30	11720	5.295	32.80	13120	5.522	36.00	14420	5.715	57.50	23000	6.955	112.50	45000	9.530
7"	9.40	3760	4.325	16.18	6470	4.826	29.10	11640	5.782	33.70	13480	6.090	37.60	15040	6.324	41.60	16650	6.560	66.25	26500	8.010	129.00	51550	10.37
8"	11.00	4398	5.050	18.25	7300	5.450	32.60	13030	6.455	37.65	15050	6.840	42.40	16940	7.125	46.05	18420	7.300	74.75	29900	9.050	146.20	58500	12.44
9"	11.62	4650	5.350	20.35	8130	6.070	36.25	14500	7.210	42.10	16840	7.600	47.22	18900	7.950	51.98	20790	8.230	83.50	33400	10.10	162.60	65050	13.84
10"	12.68	5065	5.925	22.05	8820	6.584	40.20	16100	8.010	46.70	18690	8.440	52.30	20910	8.805	57.75	23100	9.150	97.50	39000	11.18	180.00	72000	15.30
12"	15.00	6000	6.995	26.44	10580	7.890	47.40	18950	9.425	55.40	22120	10.00	61.76	24700	10.40	70.00	28010	11.14	109.30	43700	13.22	213.50	85500	18.18
14"	16.60	6635	7.625	28.90	11560	8.620	52.00	20800	10.34	60.50	24200	10.92	67.50	27000	11.36	74.10	29650	11.76	119.40	47740	14.43	233.00	93300	19.85
16"	18.82	7525	8.650	32.80	13120	9.790	58.76	23500	11.70	68.40	27320	12.34	76.10	30410	12.80	84.25	33700	13.35	135.00	54000	16.34	265.00	106000	22.55
18"	21.00	8400	9.650	36.10	14460	10.80	65.40	26150	13.00	76.50	30570	13.80	85.50	34200	14.38	93.75	37500	14.87	151.20	60500	18.30	297.50	119000	25.30

TABLE II—LOSSES FROM HORIZONTAL, BARE IRON STEAM-PIPES

From 100 Lineal Feet of Pipe per Month of 30 Days with Steam in Pipes 24 Hr. per Day. Coal at $4.00 per Ton of 2000 Lb.

In this table coal has been figured at $4.00 per ton of 2000 lb., 13,000 B.t.u. per lb of coal; labor, boiler-room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler-efficiency taken at 70 per cent; air temp. 70 deg. fahr. Experimental data obtained at Mellon Institute.

*Heat Losses from Horizontal Bare Iron Pipes.													
Temperature Difference Between Pipe Surface & Air Surrounding Pipe													
Pipe Size Inches	50°	100°	150°	200°	250°	300°	350°	400°	450°	500°	550°	600°	650°
½	2.48	2.70	2.95	3.21	3.51	3.84	4.20	4.57	4.97	5.41	5.86	6.31	6.78
¾	2.36	2.57	2.80	3.07	3.36	3.68	4.04	4.42	4.81	5.25	5.70	6.15	6.62
1	2.29	2.50	2.73	3.00	3.29	3.60	3.95	4.34	4.73	5.16	5.60	6.05	6.51
1¼	2.24	2.45	2.68	2.94	3.23	3.54	3.89	4.28	4.67	5.09	5.54	5.98	6.44
1½	2.20	2.41	2.64	2.90	3.19	3.50	3.85	4.23	4.61	5.03	5.48	5.92	6.39
2	2.15	2.35	2.58	2.85	3.14	3.45	3.79	4.16	4.56	4.98	5.41	5.84	6.30
2½	2.09	2.29	2.52	2.78	3.06	3.37	3.71	4.09	4.49	4.91	5.32	5.78	6.24
3	2.05	2.25	2.47	2.73	3.00	3.31	3.65	4.03	4.43	4.85	5.26	5.71	6.19
3½	2.02	2.22	2.43	2.69	2.97	3.27	3.61	3.98	4.38	4.80	5.22	5.67	6.15
4	2.00	2.19	2.40	2.66	2.94	3.24	3.58	3.95	4.35	4.77	5.19	5.64	6.11
4½	1.98	2.17	2.38	2.63	2.92	3.22	3.56	3.92	4.32	4.74	5.17	5.62	6.07
5	1.97	2.15	2.36	2.61	2.90	3.20	3.54	3.90	4.30	4.71	5.15	5.60	6.05
6	1.95	2.13	2.34	2.59	2.88	3.18	3.52	3.89	4.28	4.69	5.12	5.57	6.02
7	1.93	2.11	2.32	2.57	2.86	3.16	3.50	3.87	4.26	4.67	5.10	5.55	6.00
8	1.91	2.09	2.31	2.56	2.84	3.14	3.49	3.86	4.25	4.66	5.09	5.53	5.99
9	1.90	2.08	2.30	2.55	2.83	3.13	3.48	3.85	4.24	4.65	5.08	5.51	5.98
10	1.89	2.07	2.29	2.54	2.82	3.12	3.47	3.84	4.23	4.64	5.07	5.50	5.97
12	1.87	2.05	2.27	2.52	2.80	3.10	3.45	3.81	4.20	4.61	5.05	5.48	5.94
14	1.86	2.04	2.25	2.50	2.78	3.08	3.43	3.79	4.18	4.59	5.03	5.46	5.92
16	1.85	2.03	2.23	2.48	2.76	3.06	3.41	3.77	4.16	4.57	4.99	5.44	5.90
18	1.84	2.02	2.22	2.47	2.75	3.05	3.39	3.75	4.14	4.55	4.98	5.42	5.88
* B.T.U. per Sq. Ft. Pipe Surface, per Hr. per Deg. Fahr. Temp. Diff. Air Temp. 70 Deg. Fahr.													

Table III

insulation, the steam-pressure, size of pipe and the temperature of the air surrounding the pipes. The efficiency of the heat-insulation will, therefore, also vary with the above conditions.

For example, the insulating-efficiency of a good covering 1½ inches thick on a 1-inch pipe at 170° F. and 370° F. is approximately 82% and 85.5%, respectively, while the efficiency of the same covering 1½ inches thick on an 8-inch pipe at 170° F. and 370° F. is approximately 87.7% and 90.5%, respectively. This means that a good insulating-covering 1½ inches thick applied to a hot-water line carrying water at 170° F. will save from 82% to 88%

of the heat that would otherwise be wasted, while the same insulation applied to a steam-line carrying steam at 160 lbs. pressure will save from 85% to 91% of the heat that would be lost from the surface of the bare pipe.

There are several types of insulating pipe-coverings now on the market. The three most common types used in laundries are 85% magnesia, laminated asbestos coverings for the higher pressure lines, and corrugated asbestos coverings, which are very satisfactory for low-pressure steam and for hot-water lines.

The standard sizes of 85% magnesia pipe-covering and the list-prices adopted by pipe-covering manufacturers are shown in Table IV.

When insulating steam-lines, the question arises as to what thickness of insulation to use. In most cases, the result desired is the maximum net saving of money for any given condition. In a practical case, each increase in thickness would result in some slight increase in heat saved; but since the covering has a definite cost, a point is soon reached where the increased cost of the covering would be greater than the additional saving in heat effected. The correct thickness to use in a given case is shown in Table V.

This table is published through the courtesy of the Magnesia Association of America and refers particularly to 85% magnesia coverings, but can be used with satisfactory results for any type of pipe-covering having approximately the same efficiency and cost as 85% magnesia.

The table is based on a period of service of 8,760 hours per year. Where pipes are cold during part of the year, multiply the cost of coal by the number of hours per year the pipes are hot and divide by 8,760; use the value obtained instead of the actual coal cost. Twenty per cent. of the cost has been allowed as the cost of application, and 13% of the total cost for the annual fixed

charges (6% interest, 5% depreciation, 2% miscellaneous). In transforming the steam-cost to coal-cost, it has been assumed that 75% of the cost of steam is coal-cost, that one pound of coal will evaporate seven pounds of water, and that each pound of steam contains 1,000 B. t. u. above the feed-water temperature.

TABLE NO. IV

PRICE LIST

Adopted August 1, 1907

85% CARBONATE OF MAGNESIA PIPE-COVERINGS FOR WROUGHT-IRON PIPES

Nominal Pipe Size	Thickness of Standard Covering	Price per Lineal Foot Canvas Jacketed	Thickness of Covering	Price per Lineal Foot Canvas Jacketed	Thickness of Covering	Price per Lineal Foot Canvas Jacketed	Double Layer Double Standard Thickness	Price per Lineal Foot Canvas Jacketed	Double Layer Total Thickness 3 Inches	Price per Lineal Foot Canvas Jacketed
Inches	Inches		Inches		Inches		Inches		Inches	
½	⅞	$0.22	1½	$0.46	2	$0.75	1¾	$0.65	3	$1.20
¾	⅞	.24	1½	.49	2	.80	1¾	.70	3	1.35
1	⅞	.27	1½	.52	2	.85	1¾	.75	3	1.40
1¼	⅞	.30	1½	.56	2	.90	1¾	.80	3	1.45
1½	⅞	.33	1½	.60	2	.95	1¾	.85	3	1.55
2	1 1/32	.36	1½	.64	2	1.00	2 1/16	.90	3	1.65
2½	1 1/32	.40	1½	.70	2	1.05	2 1/16	1.00	3	1.75
3	1 1/32	.45	1½	.76	2	1.15	2 1/16	1.10	3	1.90
3½	1 1/32	.50	1½	.82	2	1.25	2 1/16	1.20	3	2.05
4	1⅛	.60	1½	.88	2	1.35	2¼	1.40	3	2.20
4½	1⅛	.65	1½	.94	2	1.45	2¼	1.50	3	2.35
5	1⅛	.70	1½	1.00	2	1.55	2¼	1.60	3	2.50
6	1⅛	.80	1½	1.10	2	1.70	2¼	1.80	3	2.70
7	1¼	1.00	1½	1.20	2	1.85	2½	2.25	3	2.90
8	1¼	1.10	1½	1.35	2	2.00	2½	2.50	3	3.15
9	1¼	1.20	1½	1.50	2	2.20	2½	2.70	3	3.40
10	1¼	1.30	1½	1.65	2	2.40	2½	2.90	3	3.65
*12	1½	1.85	1½	1.85	2	2.70	3	4.10	3	4.10
14	1½	2.10	1½	2.10	2	3.00	3	4.60	3	4.60
16	1½	2.35	1½	2.35	2	3.30	3	5.10	3	5.10
18	1½	2.60	1½	2.60	2	3.60	3	5.60	3	5.60
20	1½	2.85	1½	2.85	2	4.00	3	6.00	3	6.00
24	1½	3.30	1½	3.30	2	4.50	3	7.00	3	7.00
30	1½	4.00	1½	4.00	2	5.50	3	8.40	3	8.40

*All coverings larger than 10 inches furnished in segment form; jackets and bands not included.

Double standard thickness—the inner layer is furnished in sections for pipe sizes up to and including 10 inches, and in curved blocks for larger sizes. The outer layer is furnished in sections for pipe sizes up to and including 8 inches, and in curved blocks for larger sizes.

Double 1½-inch thickness—the inner layer is furnished in sections for pipe sizes up to and including 10 inches, and in curved blocks for larger sizes. The outer layer is furnished in sections for pipe sizes up to and including 7 inches, and in curved blocks for larger sizes.

85% CARBONATE OF MAGNESIA BLOCKS

For Covering Boilers and Similar Surfaces

Thickness	Price per Sq. Ft.	Thickness	Price per Sq. Ft.	Thickness	Price per Sq. Ft.	Thickness	Price per Sq. Ft.
⅞ inch	$0.30	1½ inch	$0.45	2⅛ inch	$0.64	2¾ inch	$0.83
1 "	.30	1⅝ "	.49	2¼ "	.68	2⅞ "	.87
1⅛ "	.34	1¾ "	.53	2⅜ "	.72	3 "	.90
1¼ "	.38	1⅞ "	.57	2½ "	.75	3¼ "	.98
1⅜ "	.42	2 "	60	2⅝ "	.79	3½ "	1.05
						4 "	1.20

STANDARD BLOCK SIZES

6″ x 36″. 3″ x 18″.

TABLE No. V

THICKNESS OF "85% MAGNESIA" FOR MAXIMUM NET SAVING

S—Standard Thickness. (*See Table IV, Col.* 2)

D. S.—Double Standard Thickness. (*See Table IV, Col.* 8)

COAL AT $2.00 PER TON

Size Pipe	Hot Water 175° F.	Steam 5 Lbs.	Steam 100-200 Lbs.	200 Lbs. 150° F. Superheat	200 Lbs. 300° F. Superheat
¾″	S	S	S	1½″	DS
1½″	S	S	S	1½″	DS
3″	S	S	S	1½″	DS
6″	S	S	1½″	2″	DS
12″	S	S	1½″	2″	DS
24″	S	S	2″	3″	DS
Flat	1″	1½″	2″	3″	3½″

COAL AT $4.00 PER TON

Size Pipe	Hot Water 175° F.	Steam 5 Lbs.	Steam 100-200 Lbs.	200 Lbs. 150° F. Superheat	200 Lbs. 300° F. Superheat
¾″	S	S	1½″	DS	2″
1½″	S	S	1½″	DS	2″
3″	S	S	DS	DS	3″
6″	S	1½″	DS	3″	3″
12″	S	1½″	DS	3½″	4″
24″	S	1½″	DS	3½″	4″
Flat	1½″	2″	3″	4″	5″

COAL AT $6.00 PER TON

Size Pipe	Hot Water 175° F.	Steam 5 Lbs.	Steam 100-200 Lbs.	200 Lbs. 150° F. Superheat	200 Lbs. 300° F. Superheat
¾″	S	S	DS	2″	2″
1½″	S	1½″	DS	2″	3″
3″	S	1½″	DS	3″	3″
6″	1½″	2″	DS	3″	4″
12″	1½″	2″	DS	4″	4″
24″	1½″	2″	DS	4″	5″
Flat	2″	3″	4″	5″	6″

COAL AT $8.00 PER TON

Size Pipe	Hot Water 175° F.	Steam 5 Lbs.	Steam 100-200 Lbs.	200 Lbs. 150° F. Superheat	200 Lbs. 300° F. Superheat
¾″	S	1½″	1½″	2″	3″
1½″	S	1½″	2″	3″	3″
3″	1½″	2″	3″	3″	3″
6″	1½″	2″	3″	4″	4″
12″	2″	3″	3″	4″	5″
24″	2″	3″	4″	5″	5½″
Flat	2½″	3½″	4½″	6″	7″

When using the table, determine the following factors in connection with the heated surfaces to be covered: cost of coal, steam-pressure and size of pipes.

Select the table most nearly corresponding to the cost of coal, and the column in the table nearest to the condition of steam-pressure or temperature. The thicknesses in this column are the proper thicknesses for the pipe-sizes given at the left.

Example.—Cost of coal, $5.75; steam-pressure, 15 pounds; size of pipe, 6 inches. Select the $6.00 per ton table, and the third column headed "Steam 5 pounds." Run down this column to the 6-inch line and find the proper thickness for maximum net saving to be 2 inches.

The evil of no insulation or insufficient insulation cannot be too strongly impressed upon all users of coal. The fact that pipes are covered does not end the possibility of heat losses. Unless the covering is the most efficient procurable and is applied in accordance with a scientific standard of thickness-for-pressure, as shown in the preceding table, one may still lose part of the coal-pile through condensation in the steam-lines, and every pound of condensation means practically one-fifth of a pound of coal.

There is a proper thickness of covering for every steam-pressure and temperature. Where coal is cheap, a single standard thickness of covering is ample for low-pressure lines. It is the poorest economy to use the minimum thickness on high-pressure lines where the use of a thicker covering will result not only in greater insulating-efficiency but will pay for itself quickly through the extra heat saved.

CHAPTER XI

CLASSIFICATION

Proper classification of the soiled textiles sent to the power-laundry probably has as much to do with keeping claims at a minimum as any other single factor in the industry. This is obvious from the start. In previous chapters, a discussion of the chemicals used by power-laundries has been presented. It will be remembered that some of these will injure textile fibers unless controlled scientifically, illustrating why care must be taken by the sorter in the matter of classification. Primarily, of course, the chief object of laundering soiled articles is to remove all traces of dirt, stains and other foreign matter and to return the washed linen to the customer in a clean and fresh condition. At the same time, the properties of the articles themselves must be considered, in order that they may not be abused or damaged in the wash-wheel.

From preceding chapters, we know that textile fibers that may be classed as vegetable or animal in origin (artificial silk is closely related to natural vegetable fibers) react in different ways toward the various reagents used in the washroom. Cotton and linen, for example, are scarcely affected by alkalies at the concentration used in the wash-wheel, with the possible exception of caustic soda. Wool and silk, however, may be strongly attacked by alkalies, especially at a high temperature. It is for these reasons that soap and alkali at comparatively high temperatures are used as detergents in the case of vegetable fibers (excluding artificial silk), while a neutral soap at a temperature of 100° F. is used for laundering

woolens and silks, unless, of course, the water is hard. Coming to sours, we find that those commonly used in the laundry industry, provided that they are of the concentration of the wash-wheel, are not injurious as long as the fabrics remain wet. However, in the case of sulfuric acid, sodium acid sulfate (niter cake) and oxalic acid, all traces must be removed subsequent to drying or the fibers are attacked. On the other hand, woolens and silks are little affected by sours. Bleaching agents, too, affect vegetable and animal fibers in different ways. Javel water makes an excellent bleach for cotton and linen, but has no proper use in the laundry for wool or silk. Slight concentrations yellow animal fibers; strong solutions attack them.

Briefly, then, we have reconsidered the chemical reagents used in the washroom and their action upon textile fibers. The sorter who knows why care must be taken in classifying different lots, is likely to be far more efficient because of her knowledge. Every sorter should be strongly impressed with the dangers textile fibers will be subjected to if a mistake is made in classification.

Work that comes to the average laundry, may be classified somewhat as follows:

a—White shirts and collars.
b—Colored shirts.
c—Family flat-work.
d—Colored rough dry.
e—Commercial flat-work.
f—Woolens.
g—Silks.
h—Knit underwear.
i—Overalls.
j—Curtains.
k—Fugitives, Stockings.

White Shirts.—White cotton shirts may usually be washed together unless it is known or suspected that silk or artificial silk has been used in their manufacture. Occasionally, shirts are sent to the laundry which have every appearance of being all cotton, but which are found upon close examination to have a silk filling, real or artificial. Mercerized cotton shirts in many cases have the appear-

ance of silk or rayon garments. The sorter, when in doubt, should examine the neck-band of a shirt, as sometimes shirt manufacturers print a warning to wash the garment in warm water with neutral soap. It is to be hoped that shirt-makers will universally adopt this method of assisting laundryowners in handling such materials. Other shirtings containing silk stripes must also be handled carefully. Needless to say, any garments suspected of containing silk should never be bleached and should be laundered at a temperature of about 100° F. Before leaving the subject of artificial silk and its treatment, the following table indicates why care must be taken when handling fabrics containing such fibers. It will be noted that artificial silk becomes very much weaker when wet out with water.

Strengths of Artificial Silks Made by Different Processes

Type	Raw Materials Used Process	Dry Tenacity	Wet Tenacity
		grams per denier	grams per denier
Cuprammonium	cotton	1.30	0.50 (a)
Nitro-cellulose (1).....	cotton	1.40	0.36 (a)
Nitro-cellulose (2).....	cotton	1.48	0.31 (b)
Viscose (1).....	wood-pulp	1.40	0.55 (a)
Viscose (2)....	wood-pulp	1.75	0.75 (a)
Viscose (3).....	wood-pulp	1.39	0.47 (b)
Natural silk.....		2.50	2.00

Note—Work labeled (a)—Wilson.
Work labeled (b)—Wheeler.

(*Fifth Report on Colloid Chemistry*, British Association for the Advancement of Science, **1923.**)

The weaving qualities of a shirting often have a great deal to do with its behavior in the wheel. Plain weaves, naturally, are the strongest types of fabrics, due to the intimate interlacement of warp and filling, and give practically no trouble. Modifications are bothersome, however. Loose weaves should be examined care-

fully before being sent to the washroom, and if it is at all doubtful whether garments made of such fabrics will withstand treatment in the wheel, they should be washed by hand. One type of shirting that generally gives trouble to laundryowners is the Bedford cord. This type of weave is occasionally met with in the bosoms of dress shirts and generally may be recognized by cords or ribs running in the direction of the warp. These cords are rendered more prominent by inserting wadding threads, which are held in place loosely at the back by certain filling threads. The result is a beautiful but very weak garment which should be washed by hand.

Collars.—Collars, soft, semi-soft and starched, may all be washed together in the wheel, except soft collars containing silk. At the high temperature naturally maintained when laundering such work, especially with the use of soap and alkali as detergents, and of Javel water as a bleach, the silk would be ruined.

Colored Shirts.—Colored shirts should be washed separately and great care must be taken when classifying them. Not only must the remarks under white shirts apply in this case, but the properties of the dyestuffs used must be considered as well. The bulk of dyestuffs used in coloring cotton goods may be divided into five and possibly six classes: first, basic colors; second, direct cotton colors; third, diazotized and developed colors; fourth, sulfur colors; fifth, reduction vat colors; and sixth, aniline black. It is doubtful, however, whether many basic colors are used today for shirtings, either in solid shades or in stripes, due to the fact that they are not fast to light and have a tendency to crock or rub. Where they are used the colors are bright and have one advantage in that they withstand a Javel bleach fairly well. It also is doubtful whether many shirtings are colored with direct cotton colors without being after-treated. It is a property possessed

by certain dyestuffs belonging to this class, to be rendered faster to light when after-treated immediately following dyeing with copper sulfate ($CuSO_4$) and acetic acid at 140° F. The shade is altered but is rendered much faster. Potassium dichromate or sodium dichromate ($Na_2Cr_2O_7$) increases the fastness of certain direct cotton colors to washing, and a mixture of the chromium salt and copper sulfate often is used together with acetic acid to improve fastness both to light and washing. Formaldehyde (HCHO) and acetic acid are sometimes used for this purpose. It may be said that direct cotton colors as a class, if after-treated, are moderately fast to the washing process but fugitive to the Javel bleach.

Certain direct cotton colors may be diazotized in the cold with nitrous acid (formed by the action of dilute hydrochloric acid upon sodium nitrite) and then developed in a separate bath with such compounds (called developers) as alpha and beta-naphthols, meta-phenylenediamine, etc. The result is that the shade is entirely changed and a fast color is obtained. For example, primuline, which is a yellow direct cotton dyestuff, becomes a bright red upon being diazotized and then developed with beta-naphthol. Diazine black II is a navy blue when dyed as a direct cotton color, but is black upon being diazotized and developed.

Sulfur colors are fast to light and washing and, together with after-treated direct colors, are used to quite an extent in the manufacture of shirtings. Unfortunately, this class of dyestuffs also is fugitive to chlorine. For this reason, the laundryowner should use discretion about his bleach, and, to play safe, should omit it entirely.

Reduction vat colors alone withstand the Javel bleach. Indigo is an example of this class of dyestuff. With the gradual increase in the production of reduction vat colors by dyestuff manufacturers in the United States, it may

some day be possible for all colored material used as shirting to be dyed with this type of color. It has been found extremely difficult to piece-dye cotton material with reduction vat colors; but since the bulk of colored shirtings consists of stripes or checks, it is possible to apply these fast colors to yarns and weave them into the fabric afterwards. It goes without saying that fast colors should be used for shirtings.

Aniline black finds limited use in the production of material that is used for shirtings. It may be used for black stripes and checks, rivaling sulfur black in this respect. It has one advantage over the latter in that it is quite fast to the chlorine bleach.

Artificial silk is generally dyed with the same class of dyestuffs as cotton, so that the remarks concerning their properties with regard to cotton apply to artificial silk as well. Natural silk, when colored and used as stripes or as filling, is generally dyed with acid colors. These dyes give shades that will safely withstand a light soap treatment at 100° F. Bleaching, as stated before, should be omitted.

Although it is true that many laundryowners wash white and colored shirts in the wheel at the same time, such a practice certainly is not to be recommended if the life and beauty of the colored goods are to be conserved. Unless the dyed material has been colored with reduction vat colors and aniline black, in time, and after repeated bleachings, the shade is deadened and with certain classes of dyestuffs is almost completely removed from the fiber by the action of bleach. It is because of these facts that the use of Javel water in the laundering of colored shirts should be omitted. The remarks concerning dyed materials applies equally well to prints. If the sorter is at all doubtful concerning the fastness to washing of a garment, it is an easy matter to wash a portion of the article, as, for ex-

ample, the tail of a shirt, to see whether or not the color tends to run badly. The dyestuffs used for shirting are growing better in quality every year, but it is doubtful that the cheaper shirtings, for example, will ever be dyed with the fastest and at the same time the most expensive colors, regardless of the amount on hand, unless the cost of using such dyestuffs is materially reduced. Cheap goods will always be dyed with cheap colors. And since it is impossible to determine the colors that have been used simply by looking at the dyed material, proper care should be taken that their beauty is not destroyed in the wheel.

Family Flat-Work.—Family flat-work includes sheets, pillowslips, counterpanes, table-tops, napkins, towels, wash-cloths, handkerchiefs, doilies, centerpieces, dresser-scarfs, etc. In almost every case these consist of bleached materials. Occasionally, table-tops that are unbleached are sent to the laundry. This is oftentimes the case with linen. Sometimes colored tablecloths are used, especially for kitchen tablecloths. Needless to say, the bleach should be omitted in such instances. Towels may be white or may have a colored design woven into the border. This is nearly always true of huckabuck towels, whose colored borders will withstand the Javel bleach quite well. Many towels are embroidered by hand with colored artificial or real silk threads, and unless the laundryowner is especially careful with his treatment of such articles, the colors run and the whole piece is spoiled. Centerpieces, dresser-scarfs and doilies also fall into this classification and in many cases should be treated as fugitives. They should be washed by hand, owing to the presence of colored embroidery. Cotton and linen handkerchiefs usually are made of bleached material. Many, however, have a colored border or embroidered initials that must be taken into consideration. Ladies' handkerchiefs sometimes are made of solid shades that may or may not withstand bleaching.

As said before, the weave itself should be examined and if it is at all doubtful that a certain type of fabric will withstand treatment in the wheel, even if washed in nets, it should be treated as a fugitive.

In many laundries, flat-work of all types is washed together in one wheel. Some laundryowners separate the table linen and towels from the rest of the flat-work. This is found necessary in case flat-work is blued, as due to the looseness of the weave of such articles, they tend to absorb the bulk of the blue added to the wheel. However, there is no sanitary reason why table-tops and sheets, for example, should not be washed together. The temperature of the wheel, combined with the action of soap and alkalies, kills all bacteria, and, in addition to this, the heat of the tumblers, flat-work ironers, and presses is more than sufficient to destroy any pathogenic germs that may possibly survive the treatment received in the wash-wheel. Handkerchiefs are sometimes washed in small nets with the rest of the flat-work, while some laundries wash them with the collars.

Colored Rough-Dry.—Colored rough-dry generally consists of shirts and boys' waists, ladies' and children's dresses, bungalow and other aprons, colored pajamas and similar articles that should in no case be bleached. The discussion with regard to the dyestuffs used in shirtings applies equally well here. However, it is well to remember that such materials as aprons and colored pajamas, especially the cheaper grades, are generally dyed with less expensive dyestuffs, and consequently will not withstand laundering in as satisfactory a manner as fast dyed shirtings, ginghams, etc. And in this connection it would be well to remember also that, even if it were in some way decided that all cotton material should be dyed with fast colors, it would be impossible to carry out such a plan, due to the fact that dyestuff manufacturers are not equipped to produce the amounts of fast color that would

be required and that textile manufacturers have not the equipment in their plants to handle such dyestuffs exclusively. Furthermore, many types of fabric are required to be fast only in certain respects. For example, stockings should be fast to laundering and perspiration, but need not be especially fast to light. Cheap calicos and percales, for instance, are not expected to withstand light and laundering as do the more expensive ginghams that are dyed with vat colors. Cheap articles are sold as such, unless they are deliberately misrepresented.

These are points that are often overlooked in the hue and cry that is being raised with regard to the use of fast colors. And, in any event, the laundryowner is concerned chiefly in returning soiled linen to his customer fresh and clean, without attacking either the colors or the fabrics. If colored material is sent to the laundry that would bleed regardless of whether the washing were done in the wheel or by the housewife, the laundry cannot be held responsible, unless, as a result of improper classification, the garments were overtreated. The chief thing to watch when laundering colored material is whether or not the dyed portions will run so as to stain other fabrics that are being washed with it. This is one very good reason why white goods and colored articles should not be laundered in the same wheel at the same time unless it is known absolutely that the colors will not bleed and stain the white goods. When dyed material tends to bleed or run—and this is often true of heavy dark shades —the lightest of treatments should be given.

Commercial Flat-Work.—Commercial flat-work consists of the towels, aprons and caps from towel-supply houses, and the napkins, tablecloths, and towels sent by restaurants and clubs. Hotel work, including the above and sheets, spreads and pillow cases, also falls into this classification. Commercial work is usually kept separate from family and bundle work. When the laundry is

large enough, a separate commercial unit is organized, and since everything except coats, aprons, caps, etc., is handled by the flat-work ironer, this permits of prompt service.

Hospital work is often sent to laundries under this heading. Sorters should especially watch for stains when classifying such material, as many of the medicines used in hospitals are highly corrosive and attack cotton or linen. Stains should always be reported to protect the laundryowner in the matter of adjusting claims, should holes appear later.

Woolens.—Woolens naturally call for a different treatment than cotton or linen, due to the nature of the fibers. The chief thing to avoid when handling woolens is shrinkage. It is for this reason that a very high suds is required in the wheel and that the temperature must be kept down to 100° F. The drying operation must be watched as well, since woolens tend to shrink in the tumbler if dried to bone dryness. Classes of woolens sent to laundries include woolen underwear, shirts, sweaters, blankets, dresses, stockings, etc. Woolen shirts are generally dyed with chrome colors and will withstand washing very well. Sweaters may be chrome dyed but may also be acid dyed, especially if they are ladies' sweaters. This is another reason why the temperature in the wheel should be kept down to 100° F. and why very little alkali should be used. In the textile and shoddy trade, acid colors are often stripped from wool by the use of ammonia in lukewarm water. Since soda ash, trisodium phosphate and other alkalies have the same property in this respect as ammonia, care naturally must be taken when using such reagents. Chrome colors, on the other hand, are quite fast to alkalies. Blankets also require a light soap treatment. As a rule, colored blankets withstand a soap and alkali treatment (in case the latter is needed to counteract hard water) since the

yarns used for decoration are generally chrome-dyed. Chrome colors are almost a necessity in such work, since in the manufacturing of blankets they are fulled with soap and alkali, for the purpose of shrinking the blanket and developing body. Hence, it is natural to assume that if colored blankets will withstand fulling by the manufacturer, they will withstand soap treatment by the laundry. To handle blankets successfully, enough space should be available to air-dry them and to permit re-napping. A hand card is quite suited for this purpose.

Ladies' and children's woolen or worsted dresses are sometimes sent for laundering. Here, too, the temperature and amount of alkali used must be carefully controlled. Ladies' dress goods, even in the better grades, are usually acid dyed, since fastness to light and street-dust (which is alkaline in its nature) is usually sufficient. And, as stated before, since alkalies tend to strip acid colors from wool, great care must be taken when using alkali with soap in the wheel. If the water is soft, it probably will not be necessary to use alkali at all; but if it is hard, a slight amount must be added.

Many types of material are placed on the market which contain only a certain percentage of wool and the rest cotton. Even in these cases, the articles should be laundered as all-wool fabrics. Sweaters are often made of merino yarns, which are manufactured by carding and spinning cotton and wool fiber together into one yarn. Usually such material is dyed in the raw stock, i. e., as it comes from the bale and before the two kinds of fibers are mixed, carded and spun. The cotton is generally dyed with direct cotton colors, and since it is going into a cheap grade of material, is seldom aftertreated. The wool may be acid or chrome-dyed, depending a great deal upon the shade required. Naturally, a sweater made of such yarns will bleed appreciably in the wheel and consequently the lightest of treatments is required.

Dress materials of the cheaper grades often contain a cotton warp and worsted filling. Usually the cotton is dyed either with sulfur colors, diazotized and developed colors, or aniline black, and consequently is well able to withstand treatment in the wheel. The worsted filling is then cross-dyed with acid dyestuffs, sometimes to produce a two-colored effect and sometimes to produce a solid shade. Occasionally, the cotton warp is slightly affected by the boiling bath necessary for cross-dyeing, thus requiring a cold-dyeing process with colors that dye cotton to the exclusion of wool, to bring the material up to shade. Dyestuffs used for this purpose are not especially fast to washing. Woolen underwear and stockings will be discussed later under different headings.

Silks.—Silks also require great care in handling. Under this classification, we find silk waists, undergarments, night gowns, pajamas, scarfs, etc. With such types of garments careful examination before washing is of prime importance, especially since the appearance of a silk garment is a very poor characteristic by which to judge the strength, wearing and washing qualities. Many garments, for example, which to the casual observer appear as natural silk, may contain a fairly high percentage of artificial silk that is very much weakened when soaked in warm water. This is an important reason why care must be taken when handling wet silks. The fastness of the color must be assured. Natural silk is generally although not always dyed with acid colors and is well able to withstand a light treatment with neutral soap. Artificial silk is dyed with cotton colors.

The laundryowner must also consider the probable effect of storage and shop-wear on certain heavily weighted silk. In the weighting of silk, for any other color than black, stannic chloride ($Sn\ Cl_4+5H_2O$) is used. Silk has the power of adsorbing considerable quantities of tin from solutions of stannic chloride standing at 53° to

54° Twaddle (38% to 39%.) After soaking, it is washed and hydro-extracted. During the washing process, some of the tin becomes fixed as stannic hydroxide, since the chloride is decomposed by hydrolysis with water. After washing, the skeins are treated for half an hour in a cold bath of sodium phosphate at 11° Twaddle strength (specific gravity, 1.055.) They are then washed, extracted and the process repeated until sufficient weighting is obtained. Finally, the skeins are worked for an hour in a cold bath of sodium silicate (11° Twaddle) and washed.

However, the weighting process which has been described so briefly cannot be carried beyond a certain point without the risk of damaging the fiber. This damage becomes more evident in the event of storage and wear, as stains and tenderness are very apt to result. In the first place, silk is very sensitive to the action of hydrochloric acid, which tends to form if all the stannic chloride is not removed by washing. Sometimes salts of weaker acids, such as sodium acetate, formate, etc., are added to the final wash bath to prevent such action by replacing the hydrochloric acid with acetic as soon as it is formed. However, the trouble is not altogether due to the presence of unremoved stannic chloride. It has been stated that while stains and tenderness may be due to the formation of hydrochloric acid by the hydrolysis of stannic chloride, they are in most cases due to hydrolysis of sodium chloride, followed by the oxidation of the acid to free chlorine. This conclusion is supported by Sisley (*Journal of Society of Chemical Industry*, **1913**, p. 23) and by Dreaper (*Journal of the Society of Chemical Industry*, **1912**, p. 34.)

Stains should always be noted before washing and reported, because, as stated above, they are often corrosive in their nature and are removed during the washing pro-

cess. In such a case, they leave no evidence of the true cause of the damage.

It is strongly advisable, therefore, to wash every new silk article the first time by hand, so that its washing qualities may be observed. It would be a wise precaution to accept silk articles for the first washing only at the owner's risk, since so many of these articles are not guaranteed to withstand water-washing. Good silk should withstand washing with ordinary neutral soap and water. A temperature of not over 100° F. should be used and soda ash and Javel bleach should be omitted.

If a sour is required for a small load of white silk goods in a pony wheel, one ounce each of sodium bisulfite and acetic acid dissolved in one gallon of water may be used to advantage.

Knit Underwear.—In the simplest form, a knit fabric is composed of a series of loops hung in rows one upon the other and constructed from curvings of a single thread that runs continously through the fabric. As one row of loops is formed, it depends for strength and support on sets of stitches above and below it. It is for this reason that a broken thread in knit goods means a much larger opening than does a broken warp or filling thread in a woven fabric. This is the great defect of knit goods; but when one considers the number of uses to which knit fabrics have been put, both as under and outergarments, the advantages must more than off-set the disadvantages. A knit fabric is essentially a filling fabric, the thread being inserted crosswise into the texture, as is also the case with filling inserted through the warp of a woven fabric. Woven cloth is adaptable for certain uses, while the stretch and elasticity of knit goods make this class of material valuable for other purposes.

Knit underwear appears on the market in a number of forms. All-cotton fabrics are, of course, sent to laundries in greater quantities than those of any other

class. However, every laundryowner occasionally runs across knit garments consisting of cotton and artificial silk, cotton and wool, and sometimes cotton, silk, and wool. Artificial silk is now known as "rayon" in the textile trade.

Cotton underwear is made in a variety of styles and forms. White or bleached knit underwear is probably manufactured in the greatest quantities, especially for women and children. Such garments include undershirts, undervests, and union suits. Knit underwear is made in the form of a roll, bleached and then cut up into garments afterwards. Colored cotton knit underwear for women may be sent to the laundry at times, such shades as pink, lavender, pearl and wool-color being the more common. However, such undergarments were more numerous in the past than they are now. Usually they are dyed with direct cotton colors and consequently should never be bleached in the wheel.

There is another type of dyed cotton underwear that is used chiefly for boys' and men's suits. This is the so-called Egyptian shade. This type of garment may be manufactured from Egyptian cotton, which is naturally colored so that material made from it is a light buff or tan. Because of the length of staple, the wearing qualities of underwear made from such a grade of cotton are excellent. Unfortunately, the supply of Egyptian cotton is limited. Hence it is common practice for manufacturers to knit underwear with yarns made from upland cotton and then to dye the half-bleached rolls to identically the same shade as true Egyptian cotton. Light weight rolls are usually dyed in the piece, direct cotton colors being used as a rule. Heavy weight garments, however, are made according to another system. A certain percentage of a batch is dyed in the raw stock to a considerably heavier shade than lightweight piece goods. After drying, this dyed portion is mixed with white cot-

ton, carded and spun until finally the yarn is the same shade as if dyed in the piece. For instance, 15% of colored raw stock might be mixed with 85% undyed cotton stock, the resulting 100% equaling the required shade. It should be remembered that underwear dyed with direct cotton colors will not withstand repeated washing, especially if the laundryowner insists upon adding bleach to the wheel.

Another type of undergarment met with frequently in the laundry is the so-called random-dyed garment, which is made to imitate worsted suits, but which consists entirely of cotton. A mottled gray and white effect is produced which closely resembles worsted. Still another type of cotton underwear is made by mixing a certain small percentage of black raw stock with white. The black may be sulfur dyed, giving a shade fast to washing but not to bleaching, or it may be dyed with Direct Black. If after-treated with formaldehyde and acetic acid or with copper sulfate and acetic acid, the shade is rendered much faster.

Still another type of cotton underwear consists of two-ply yarn composed of a white thread and a black thread twisted together. Unless the black has been sulfur dyed or after-treated, in case a direct black has been used, the resulting shade will not be especially fast to washing. Such garments are worn by miners and steel workers and consequently require a strong treatment in the wheel to remove all the dirt.

Fleece-lined underwear is a heavy garment in which a nap has been raised on the portion touching the skin. This produces a heavy and warm suit.

Cotton and artificial silk are sometimes used in the manufacture of women's and children's knit undergarments. This may be bleached material or colored. One type of garment consists of rather fine-count cotton, knit with artificial silk stripes and dyed in the piece to give

it the creamy color of pure wool. Sometimes this grade of underwear is dyed flesh color and pink.

Occasionally, we find underwear consisting of silk and wool. In some cases, the silk is organzine; in others, it is a two-ply spun-silk. These are produced in silk manufacturing from cocoons which have been damaged so as to cause the silk fiber to be broken or torn. Spun-silk is extremely elastic and hence is very valuable for knitting. The silk yarn, single or ply, is twisted as a rule with singles wool, loosely spun to give an open effect. In this type of fabric, the gloss and the lustre of silk beautify while the woolen yarn gives body and warmth to the fabric. It must be admitted that such a fabric is seldom met with in the power laundry, but if it should be encountered the greatest of care must be taken.

Cotton and wool are sometimes used together. A pure wool undergarment is an irritant to the skin of many people. On the other hand, garments consisting entirely of cotton do not possess the necessary heat-retaining power of wool and are not so elastic nor absorbent. Hence, the two fibers are blended to give to the knitted suit some of the benefits to be derived from each fiber. The result is that a garment is produced that is warmer than cotton but not as warm as wool. As in the sweater trade, the yarns used are termed merino yarns. The usual kind of merino used for underwear is two-ply, with a slack twist that seldom exceeds a few turns to the inch.

Cashmere yarns were originally the product of the cashmere goat of Northern India, but have long since included the worsted yarns used in the manufacture of underwear. Lamb's wool is another name that is likely to be a misnomer and includes such yarns as are spun from the shorter staples. A good grade of underwear is made from such woolen yarns but considerable care must be taken during laundering.

The laundering of knit underwear has, in the past, caused much trouble to the laundryowner. Every one has had instances in which one suit in a load of say one hundred pieces, has shrunk when every piece in the wheel was treated in identically the same manner. And surely we cannot be blamed if we maintain that such results are not the fault of laundering. Temperature is the first point to watch. It should never go over 120° F., and if any wool is present 100° F. should not be exceeded. It is advisable to use a high suds with wool. Fleece-lined underwear should be washed in the same manner as wool or part wool suits.

Before closing the subject it would be well to state that the use of artificial silk is increasing each year and that more and more of it is being used in conjunction with cotton, wool and natural silk in the manufacture of knit underwear. A high water level should be used and the operation of drying controlled carefully.

Stockings.—Stockings are placed on the market as cotton, silk, wool, cotton and silk, wool and silk, cotton and artificial silk, and wool and artificial silk hose, and naturally the dyestuffs used for these many classes are different and give varied reactions during laundering. Sometimes a combination of three fibers is used.

There still is a great demand for cotton hosiery, especially for children. Black is the chief color and is dyed with Direct Black, Aniline Black or Sulfur Black. At present, however, a relatively small percentage of hose is dyed with direct dyes, as other methods produce faster shades at practically no increase in cost. Aniline Black is no longer used in the immense quantities of former years since its method of application is very complicated. And so Sulfur Black dyeing, for hosiery mills, is the most important method of application as far as blacks are concerned. It produces shades fast to laundering. Colors other than black for cotton hosiery are chiefly brown and

navy blue. Direct cotton colors are used for the most part, due to their cheapness and ease of application. Such shades, including Direct Black, are not very fast to laundering, however. Increased fastness could be obtained by applying diazotized and developed colors; but since cotton hosiery is sold at such a low price, stocking manufacturers do not consider that the increased cost of using faster colors is justifiable. Sulfur browns and blues have been recommended, but considerable trouble has been experienced in their application, especially in the case of sulfur blues. Much all-cotton hosiery is bleached, particularly in the children's hose trade, chloride of lime or liquid chlorine bleach being used.

All-silk and cotton and silk hose occupy places of chief importance in the manufacture of high grade hosiery. During the last few years the demand for silk hosiery has been enormous. Great care is required in the manufacture of this type of goods, black being by far the largest seller in the silk line today. At one time Direct Black was used almost exclusively, but lately developed blacks have replaced them to a great extent due to superior fastness. The dyeing of developed black is a long procedure requiring about five hours, which may possibly explain why hosiery manufacturers are not anxious to use developed colors on cheap cotton hose. Browns are next in importance for high grade work.

The action of dyestuffs adapted to silk and cotton unions depends largely upon the water used in dyeing. Most direct cotton colors dye silk deeper than cotton in hard water at a boil, which makes it advisable to add a small amount of soda ash as a corrective agent. Best results are obtained in soft water, as the cotton is dyed level and the depth of shade is easily regulated by choice of dyestuffs, amount of salt and length of boil. Direct colors of superior fastness to washing, dyed direct or after-treated, have been used during late years. After-

treatment is usually avoided, due to the fact that the shade is generally affected. As comparatively little increase in the cost of application results, it is probably only a question of time until the faster direct colors are adopted by cotton-silk hosiery manufacturers in general.

Of recent years there has been a growing demand for light shades on the part of the consumer. This has caused the hosiery dyer a great deal of trouble, due to the difficulty experienced in obtaining level shades. Generally, direct cotton colors are used exclusively, although acid and small amounts of basic dyestuffs may be used for shading. Since most hosiery dyehouses use soft water that is alkaline in reaction, the use of neutral-dyeing acid colors is impossible unless considerable salt and a small amount of acid are added. The great difficulty in dyeing such shades is to get the toes and heels of the stockings thoroughly penetrated.

White silk hosiery is bleached with either hydrogen peroxide or sodium peroxide, the former, although more expensive, being safer.

Silk stockings usually give little trouble when laundered. Naturally, a low temperature must be used in the wheel and no alkali should be added unless the water is hard. Very light shades, especially on mixed fibers, sometimes fade after only a few washings.

Hand in hand with the great demand for silk hosiery has come a tremendous popularity of woolen hose. Until recent years very little wool hosiery was marketed except for lumbermen's socks. At present, however, manufacturers are producing large quantities of all-wool, wool and silk, wool and cotton, and wool and artificial silk hose. Sometimes these are sold as solid shades as well as two-toned and heather effects. All-wool hosiery is produced in large quantities in heather mixes, each color being dyed as rawstock with chrome colors. A mixture is then carded and spun into yarns. Sometimes solid

blacks or browns are manufactured, fancy effects being produced by knitting or by the employment of clocks.

Wool and silk mixes, with cotton toes and heels, are also in great demand. These are made in solid shades and in two-tone effects. Solid shades may usually be dyed in a single bath, by the proper selection of dyestuffs and control in the matter of salt and temperature. Many direct dyes give fast colors on wool when after-treated in a fresh bath with sodium dichromate and acetic acid. Black, in the case of wool and silk mixtures, is generally obtained by using a direct black and a neutral dyeing acid black in combination with it.

When two-tone effects are required, the process becomes much more complicated. If fast colors are required, it is necessary to dye cotton and silk previous to knitting. Fairly satisfactory results, however, are obtained by first dyeing with a chrome color that leaves silk white; the silk may then be dyed in a warm bath with acid or basic colors.

Wool and cotton two-colored effects may be dyed in one bath by a combination of suitable direct, union, and neutral wool colors, but unless controlled scientifically one fiber is likely to be stained. It is because of this difficulty that a two-bath method is employed as a rule. The wool is first acid dyed, and then the cotton is colored cold with dyestuffs that do not stain wool at such low temperatures.

Recently stockings consisting of a combination of artificial silk and worsted have been manufactured in large numbers. These two fibers may be found in a variety of styles. For instance, they may be mixed, carded and spun together; or an artificial silk and a worsted yarn may be twisted together to form another type of knitting thread. Another style consists of plaiting so that the outside of the stocking is artificial silk, while the inside is wool. These effects may be accentuated by

dyeing. Solid shades are generally produced by the one-bath method, union colors being used. These dye vegetable and animal fibers practically the same shade from a neutral bath. However, artificial silk has a greater affinity for such colors than cotton has, and to offset this the hosiery dyer must often add a small quantity of neutral-dyeing wool dyestuffs to bring the wool up to shade. When two-color effects are desired the dyer may use one of two methods. First, he may use the single-bath method in which neutral colors are used in combination with direct cotton colors which dye cotton to the exclusion of wool. Or he may use the two-bath method and dye the worsted with acid or chrome colors and then dye the artificial silk in a fresh bath with direct colors at a low temperature. Faster shades are produced by the latter method, especially if chrome colors are used, but the process is much longer.

When laundering such stockings great care must be taken, as the artificial silk loses a great deal of its strength when wet. Stockings should be turned inside out before being sent to the wheel.

CHAPTER XII

STANDARD FORMULAS FOR WASHROOM PRACTICE

Everyone who has observed the degree to which fabrics are soiled, and the nature of the dirt on them, knows that a certain percentage of the total "bundles" going through the washroom may be washed thoroughly clean with ease while other bundles can be turned out clean only by the most careful and thorough washing. Obviously, the purpose of laundering is to convert dirty fabrics into clean ones at the least cost to the physical quality of the fabric. Some fabrics are soiled with materials that cannot be removed without unduly injuring the fabric but there is only a very small percentage of such pieces.

A washing formula, to be successful on a working commercial basis, must, of necessity, wash clean practically 100% of the fabrics of the "lot." Suppose a lot to contain 30 bundles, 5 of which have come from homes where the workers are employed in a steel-mill or railroad yard, while the other 25 bundles are from homes where the workers follow clerical or professional pursuits. In this particular lot, 83% of the bundles should be washed clean very easily, whereas the other 17% must receive special attention. The question now arises: Should the washing formula be designed to thoroughly wash the 83% of the bundles, but only wash the very dirty 17% of the bundles in a mediocre or poor manner? It is the poorly washed bundle that causes "go-backs" and go-backs should be avoided because they seriously hamper efficient production.

Bundles should be separated into two classes, one including the slightly soiled bundles and the other the more heavily soiled.

From the laboratory viewpoint, we have always recommended a two-suds formula, due largely to the fact that the common practice in the trade was to use two suds. It has been found, however, in the American Institute Laundry that three suds are better than two, and that in the case of extremely soiled bundles four suds are advisable. It has also been found that only about 30% more soap and soda are required for four suds than for two suds.

The question now arises as to why four suds should do better washing than two suds. The explanation is this: From actual measurement with a 277-pound load of flat-work, exclusive of nets, it was learned that 151.7 gallons of water are required in the first bath, to bring the water level to a height of four inches. Suppose that 20 ounces of soap and 7 ounces of soda ash are added to produce a suds. The concentration of soap in the water then would be 1/10 of 1%, while the concentration of soda ash would be approximately but one-third of that. The concentration of soap and soda is adequate to remove a portion of the dirt from the fabric and hold it in suspension or in an emulsion, but is there sufficient soap in the wheel to hold the dirt free from the fabrics when the soap solution becomes diluted in the baths that follow? Further measurements demonstrate that when the first bath has been run from the wheel 58.9 gallons more water must be added to bring the height of the water back to the four-inch level. It must then follow that if 58.9 gallons were added to bring the water back to the original level of four inches, 58.9 gallons had been dumped from the wash wheel after the first bath. In other words, the difference between 151.7 gallons and

58.9 gallons or 92.8 gallons were left in the wheel. This amounts to 61% of the original volume. It may then be estimated that about 61% of the soap and soda originally added also would remain in the wheel. It may be said that, by continuing to add soap in the third and fourth bath, the soap concentration will be kept high enough throughout the washing formula so that the dirt may be rinsed from the garments.

When the soap concentration is permitted to drop due to the great dilution of the solution by rinsing, if only two suds are used, the dirt is not in the proper state of suspension or emulsion to make good rinsing possible. Naturally, the amount of soap required in any one bath will depend on the amount of loose dirt in the fabric, for the more soiled the bundles, the greater the need for additional suds.

As an example of the difference in the washing formulas to be applied to the moderately soiled and the very dirty bundles, respectively, the following are given as suggestions. In fact, these formulas have been worked out in the American Institute Laundry from observations extending over a period of one year. The work is washed in nets (not over 10 lbs. of goods in a 24″ x 36″ net) in a 42″ x 84″ wheel of the latest design, that is, the cylinders have a 5″ or 6″ rib and the wheel is of the quick-filling and flushing type.

The load varies from 275-300 lbs., exclusive of nets.

From practical tests that have been conducted at the American Institute Laundry, it has been found that these same formulas are also adapted for washing without nets.

A. For Washing the Moderately Soiled Family Bundle (Cotton or Linen Flat-Work)

1st Bath.—Warm water (100° F.); 5 inches of water in wheel after load is saturated. Add the soap and soda mixture to make good suds. Run 10 minutes.

2nd Bath.—Hot water 140°-160° F.); 5 inches of water in wheel. Add the soap and soda mixture to make good suds. Run 10 minutes.

3rd Bath.—Hot water (140°-160° F.); 5 inches of water in wheel. Add soap and soda to make good suds. Apply the bleach here. Run 15 minutes.

4th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

5th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

6th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

7th Bath.—Warm rinse (120° F.); 10 inches of water. Run 5 minutes.

8th Bath.—Cold rinse; 10 inches of water; sour with one-half pint of 56% acetic acid or preferably 6 oz. of sodium acid fluoride. Blue lightly. Run 5 minutes.

Draw the load from this bath.

Total running time, 60 minutes.

NOTE: The bleach used in this formula should be equivalent to 5 quarts of a solution containing 1% available chlorine. If a solution containing 5% available chlorine is used, only 1 quart of it should be applied to the wheel.

B. For Washing the Very Dirty Bundle.—The formula in this case is identical with A (the above), except that baths 2 and 3 are run at a temperature of 190°—200° F. in the wheel.

To attain so high a temperature, the use of steam in the wheel is usually necessary.

C. Yet Another Classification of Bundles May be Made to Include Only the Very Slightly Soiled Fabrics.—This type of fabrics is washed with a formula that is identical with A, except that only one 10-minute and one 15-minute suds are required.

Detergents Used in Formulas.—The formulas are being used with water of "zero" grains of hardness. In case water of six grains or more of hardness per gallon is being used, about four to six ounces of soda-ash should be added to the first rinse after the suds.

A mixture of 2 parts of 88% neutral soap is used with 1 part by weight of 58% soda ash. If these formulas are to be used with water of about 10 grains of hardness, it is necessary to increase the proportion of soda in the deter

gent mixture so that equal parts of soap and soda ash are taken.

Selection of Proper Formula.—Too much attention cannot be given to this point of the laundering process. Whether formula A, B or C should be used will depend altogether on the type of bundle that the families in the community send to the laundry.

In the large majority of cases, formula A will give thorough satisfaction on practically 100% of the bundles. There are numerous laundries, however, where so many of the bundles are sufficiently soiled that the use of formula B is imperative.

The use of live steam in the wheels is an expensive operation and to get away from it in each lot of family flat-work bundles, it is necessary to sort the very dirty bundles from the less dirty ones in the marking room. If this were done, and it can be done, it would be possible for the marking room to send instructions, to the washroom with each lot stating whether formula A, B or C should be used.

Temperature of First Bath.—The temperature of the first bath has been given as lukewarm instead of cold, as is usually stated. The only reason why this bath should not be hot is that at a temperature of about 130° to 140° F., certain animal matter called "albumin" is coagulated, i. e., changed from a soluble substance to an insoluble substance. The white of an egg is an example of this class of substances. Many food stains on table linen and body excretions on wearing apparel are albuminous. From this, it follows that our only purpose is to avoid a temperature high enough to coagulate or cook these substances. Since more dirt is washed out by warm water than by cold water, the limiting temperature has been placed at 100° F. for this bath, thereby allowing a sufficient margin for safety. It is assumed that each laundry

has, as it should have, a standard hot-water system, or, in other words, a system that will supply an adequate amount of hot water at a temperature of not less than 180° F. It is highly important that each wheel is equipped with a thermometer, in order that the temperature may be controlled accurately.

Soap and Soda Required by Four-Suds Formula.—It might seem to the casual observer that the four-suds formula would consume twice as much soap and soda as one using only two suds, but the following data, which represent actual operating values, show differently:

Soap and soda (2:1 by weight) required for 1st suds	27	ounces
Soap and soda (2:1 by weight) required for 2nd suds	9	"
Soap and soda (2:1 by weight) required for 3rd suds	6½	"
Soap and soda (2:1 by weight) required for 4th suds	3½	"
Total supplies used	46	ounces

These are typical quantities that apply to the washing of a load in a 42" x 84" wheel. It will, then, require about 30% more soap and soda to wash with four suds than with two suds.

Observation on the Preparation and Use of Supplies.—It has been found that there is a marked uniformity in the methods of using the various supplies, it being quite generally the practice to prepare a stock solution of soda and of soda and soap. Some, however, add the soda in the dry powdered or crystal form directly to the wheel. There are certain conveniences in this practice, and it is the opinion of this Department that if proper measuring scoops are provided and if proper caution is observed in sprinkling the powder over the revolving wheel, the dry soap and soda may be accurately and economically used.

Use of Dry Soap.—There are no chemical reasons so far observed which would indicate that economy is secured by boiling the average grade of chipped soap. A large number of analyses show that the average run of

chipped soaps contains no unsaponified fat. The soap does not deteriorate during prolonged boiling, but the boiling does no good other than to get the soap into solution.

The average soap chip is sufficiently soluble to be readily dissolved in hot water (160° F.) within ten minutes after adding to the wheel. The drier the soap chips, the more readily are they dissolved in water. The finer the flakes or the finer the powder, the more readily will the soap go into solution.

The faucets through which soap solutions are drawn from the soap tank often leak. Hot soap solutions will leak through a hole that will hold water. Furthermore, when using soap solution of the strength usually employed, one gallon of solution must be conveyed to the wheel for every four ounces of soap needed. Hence, for every pound of soap conveyed to the wheel, the washman must carry thirty-three pounds of material. Reliably kept cost records have shown a saving by using dry soap over soap solution for hot-water washing. When powdered material is used, it can be kept in small boxes, one for soap and one for soda, provided with handy dippers or scoops near or on each wheel. The dippers or scoops should be selected of such sizes that the soda dipper when full will hold half the weight of soap contained in the full soap dipper. This convenience encourages the washman to add a little at a time, thus avoiding the waste of adding too much at one time. In using soap solution, there is the temptation to take plenty the first time rather than to make repeated trips to the soap-tank to add just the right amount.

The practice of making a stock soap solution of the proportions of 16 pounds of soap and 8 pounds of soda ash, or its equivalent, to 100 gallons of water, is representative of the average for a water of not more than 6 grains

of calcium carbonate equivalent per U. S. gallon. There is little to criticise in this procedure. It has, however, been maintained that an advantage will result by adding dry soap chips instead of soap solution, especially in hot-water washing. This Department has not been able to discover any chemical advantage or disadvantage in this practice, provided the chipped soap is flaked sufficiently thin. There are, however, a number of distinct advantages as to technic. The chief one among these is due to the fact that the dry chipped or powdered soap is of less bulkiness than the solution and may, therefore, be placed near the wheels, thereby saving steps for the washman, inducing him to add small quantities at a time until the proper suds is obtained.

"Running Suds" Defined.—There is occasion for fine points of distinction as to what constitutes a proper suds. For washing goods other than woolens or colored goods of fugitive shades, it is thought that a suds that will form a cushion of about 6 inches on top of the goods, immediately after the washing machine is stopped, is representative of correct conditions. Such a suds is popularly described as a "running suds."

Soda.—In this and following paragraphs, soda ash has been used as the typical soda, it being understood, of course, that equivalent portions of other sodas may be used if market conditions favor them.

Also, where stock soap solution is indicated, it is to be understood that the very dry soap and soda ash in ratio of about two parts of soap to one part of soda ash may be used if desired, assuming always a water of not over six degrees of hardness.

Piping.—It is regrettable that more attention has not been paid to standardization of piping to washing machines. Due to the wide variation in piping and water-supply pressure prevailing in laundries, it is impossible to allow time for filling and discharging the various baths

in the calculation for these formulas. It is, therefore, to be observed that the washing time specified is for actual time of running. This should be especially insisted upon in the rinsing baths. Rinses must not be slighted if good and uniform results are expected. The importance of adequately large water pipes to the washers might be profitably looked into by the managers of many plants.

Importance of Rinsing.—Rinsing is frequently regarded as merely an incident in the washing process, when actually the entire washing operation consists largely of the application of repeated rinsing baths.

Soap and soda are merely added in the first rinses (suds) to act as carriers of the dirt so that it can be rinsed from the fabrics. If there is not sufficient soap and soda in the wheel to carry off the dirt, thorough rinsing is impossible. There are certain physical conditions at which water solutions of soap and soda exert their maximum influence as dirt carriers and these physical conditions are taken into account when a washing formula is chosen. In this connection, it may be said that three or even four suds make better rinsing possible than can be expected from two suds. A very large part of the dirt has been rinsed from the load after the third or fourth suds has been run off and whatever loose dirt is left in the load will be carried off by the soap and soda present during the subsequent rinses.

Regardless of the number of rinses that may be prescribed by a washing formula, the rinses following the suds should be continued until the soap and dirt have been completely taken from the load. Sometimes four rinses, between the last suds and the sour bath, are sufficient and in other cases five or even six rinses may be necessary. The washman should catch in a clean receptacle some of the rinse water as it comes from the outlet valve and should never cease rinsing until the water comes clear. If the soap and dirt are not completely

rinsed from the load, the finished fabric will have a gray appearance.

In order to determine the efficiency of rinsing, accurate chemical tests were made in a commercial laundry some time ago one hundred c.c. of the liquor in the wheel was collected, a few drops of methyl orange added, and the solution titrated to an orange color with N/10 sulfuric acid (i. e., 4.9 grams of c. p. sulfuric acid made to a volume of one liter with distilled water). A blank titration was also made with 100 c.c. of water, since it was known to be alkaline after having been softened with zeolite. The necessary corrections were then made to the original titration values obtained. The results were as follows:

Example	N/10 H_2SO_4	N/10 H_2SO_4 (Corrected)	Soap and Soda, Parts of the Total
Water 100 c.c.	6.5 c.c.	0.0 c.c.	0.0
Suds 100 c.c.	26.0 c.c.	19.5 c.c.	100.0
2nd Rinse 100 c.c.	9.2 c.c.	2.7 c.c.	13.8
3rd Rinse 100 c.c.	7.3 c.c.	0.8 c.c.	4.1
4th Rinse 100 c.c.	7.0 c.c.	0.5 c.c.	2.5

The sample taken of the fourth rinse, after titration with acid, was clear, but the preceding ones were very turbid.

In this connection, it is well to mention the danger of overloading the wash-wheels. Similar tests were made except that the wheel was 20% overloaded. It was found that while four rinses were sufficient to remove the soap and soda satisfactorily when run to capacity, eight rinses were necessary to accomplish the same results when the wheel was 20% overloaded. In other words, eight rinses were necessary to remove the detergents used to the same extent as shown by the fourth rinse in the above table.

Manufacturers of washing machines usually specify the capacity of their machines. It is far better practice

to load machines slightly below capacity than it is to overload them.

The formulas that follow are recommended for washing the various classifications of work.

Family Flat-Work (See Page 153)

Light Colored Work in Family Bundle.—The light colored part of the family bundle may be washed by formula A, page 153, except that bleaching is omitted. This class of work should, except in extreme cases, be washed at a temperature of not above 160° F. in the wheel. Where washing is done in nets, not over 10 pounds of goods should be placed in a 24″ x 36″ net. All pieces should be well shaken out before being placed in the net. Individual pieces of flat-work should also be thoroughly shaken out before being placed in the net.

White Shirts, Collars, Cuffs and Possibly Some Other White Garments

(Only cotton fabrics included)

100-125 lb. load in 36 in. x 54 in. wheel.

1st Bath.—Warm water (95°-100° F.); 5 inches of water in cylinder after goods are saturated. Add a mixture of 88% neutral soap and soda ash (2:1) to make a good suds. Run 10 minutes.

2nd Bath.—Hot water (140°-160° F.); 140° F. in the wheel is hot enough. 5 inches of water. Add soap and soda as in 1st bath. Run 10 minutes.

3rd Bath.—Same as 2nd bath, but add 2 qts. of Javel water (1% available chlorine), after the soap and soda have been added. Run 10 minutes.

4th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

5th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

6th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

7th Bath.—Hot rinse (140°-160° F.); 10 inches of water. Run 5 minutes.

8th Bath.—Hot water (140° F.); 6 inches of water. Add 4 oz. of oxalic acid dissolved in 6 quarts of hot water. Blue. Run 7 minutes.

9th Bath.—Cold rinse; 8 inches of water. Add ½ pint of 56% acetic acid or 3 oz. of sodium acid fluoride. (patented). Run 3 minutes.

Total running time, 60 minutes.

NOTE: See formula for preparing starch to be used on collars and shirts.

Collars must be thoroughly rinsed before souring; otherwise dark spots in the corners of the collar will result.

When sizing is applied to shirts in the wheel, the last bath must be run for at least 10 minutes.

Colored Cotton Shirts and Other Colored Cotton Fabrics

Great care should be exercised in the matter of temperature when washing colored goods. The Department of Research recommends 120° F. as being the proper temperature. The goods should not be bleached nor soured with oxalic acid.

100-125 lb. load in 36 in. x 54 in. wheel.

1st Bath.—Warm water (95°-100° F.); 5 inches. Add a mixture of 88% neutral soap and soda ash (2:1) to make a good suds. Run 10 minutes.

2nd Bath.—Warm water (120° F.); 5 inches. Add a mixture of 88% neutral soap and soda ash (2:1) to make a good suds. Run 10 minutes.

3rd Bath.—Same as second bath.

4th Bath.—Same as second bath.

5th Bath.—Warm rinse (120° F.); 10 inches of water. Run 3 minutes.

6th Bath.—Warm rinse (120° F.); 10 inches of water. Run 3 minutes.

7th Bath.—Warm rinse (120° F.); 10 inches of water. Run 5 minutes.

8th Bath.—Warm rinse (120° F.); 10 inches of water. Run 5 minutes.

9th Bath.—Cold rinse; 8 inches of water. Add ½ pint of 56% acetic acid or 3 ounces of sodium acid fluoride. Run 4 minutes.

Total washing time, 60 minutes.

NOTE: Sizing for shirts may be applied in the 9th bath. Run 10 minutes. In case the shirts are extremely soiled, it may be necessary to use a temperature of 160° F.

Special Treatment of French Cuffs.—When the four suds method is applied, unless the cuffs are extremely soiled, they will usually be washed clean. In case there is

any doubt about obtaining satisfactory results, the cuffs may be dipped into hot soap solution prior to being placed in the wheel. Use a concentration of twenty pounds of neutral soap to sixty gallons of water.

In the past, the Department of Research has recommended the use of the "red oil"-kerosene-carbon tetrachloride mixture.

Preparation of Solution.—Add 1½ pints of oleic acid (commercial "red oil") to a mixture of two gallons of kerosene and one gallon of carbon tetrachloride. (Three gallons of carbon tetrachloride may be used instead of this mixture; but since its wholesale cost is about six times that of kerosene, there is an advantage in using the mixture, provided there is no odor of kerosene left on the goods.) Carbon tetrachloride is non-inflammable. A solution of oleic acid in kerosene has been recommended for this purpose in previous publications, but the objection has arisen that the odor of kerosene persists on the shirts after they have been washed and ironed. However, it is the experience of many laundryowners that the oleic-kerosene mixture, when properly used, gives satisfactory results.

Method of Treatment.—By means of a properly designed can (See *L. N. A. Bulletin* for May, 1923) treat the stained cuff with the solution prepared according to the above formula.

NOTE: Cotton shirts, after being treated with the special solution, are washed by the standard formula for colored shirts.

However, with the four-suds formula recommended here such a treatment is not wholly necessary. In the case of a two-suds formula, its use is often beneficial. Care should be taken to examine the containers, because "red oil," being acid in its nature, attacks metals so that rust spots will appear occasionally on the cuffs.

One of the chief reasons for adopting the four-suds formula is to make the use of any special treatment for French cuffs unnecessary.

Kitchen Towels, Butchers' Aprons, Etc.

100 lb. load in 36 in. x 54 in. wheel.

1st Bath.—Warm water (100° F.); 6 inches of water and 1 lb. of soda ash. Run 10 minutes.

2nd Bath.—Hot water (140°-160° F.); 5 inches. Add 1 lb. of soda ash and sufficient soap for good suds. Then add 4 qts. of Javel water, containing 1% available chlorine. Run 15 minutes.

NOTE:—It may be necessary in extreme cases to bring goods to a boil in this bath with steam. A third 10-minute hot suds without bleach may also be advisable in extreme cases.

3rd Bath.—Hot rinse (140°-160° F.); 8 inches of water. Run 5 minutes.

4th Bath.—Hot rinse (140°-160° F.); 8 inches of water. Run 5 minutes.

5th Bath.—Hot rinse (140°-160° F.); 8 inches of water. Run 5 minutes.

6th Bath.—Hot rinse (140°-160° F.); 8 inches of water. Run 4 minutes.

NOTE:—Add another rinse if necessary.

7th Bath.—Cold rinse; 6 inches of water and ½ pint of 56% acetic acid or 3 oz. of sodium acid fluoride. (Patented, see page 169). Run 5 minutes. Load may be drawn from the sour bath.

Overalls

Overalls should be washed in a wheel that has deep ribs so as to insure thorough agitation of the load in the wheel.

100 lb. load in 36 in. x 54 in. wheel.

1st Bath.—Hot water (180° F.); 6 inches. Add 5 lbs. of soda ash and 8 lbs. of common salt. Run 15 minutes.

2nd Bath.— Repeat

Rinse in the usual manner until the rinse water runs clear and sour with one-half pint of 56% acetic acid or 3 oz. of sodium acid fluoride. (Patented, see page 169).

Woolens.—Woolen and worsted material must be handled carefully if satisfactory results are to be expected during laundering. The greatest trouble that the laundry-owner faces when washing such material is shrinkage, which occurs regardless of whether the fabric is woven or knit, unless certain precautions are taken.

Wool is a fiber that is peculiarly sensitive to the action of soap, alkali, heat, moisture and pressure. Even dilute solutions of caustic soda are injurious to wool. Next in its action upon wool is soda ash and then trisodium

phosphate. Borax and ammonium carbonate probably have the least action upon wool of any of the alkalies now in use.

A number of theories have been advanced to explain the felting of wool. Some authorities state that felting is due to an interlocking of the wool fibers. A more recent theory states that felting is the result of the various fibers intertwining and becoming "glued" together. The outer epithelial portion of a woolen fiber is closely related to gelatin and glue. When treated with soap and moisture this layer softens, so that under pressure the fibers are cemented together. But regardless of the theory of felting, the results obtained are disastrous.

Pure wool or part wool fabrics should be washed at a uniform temperature throughout the entire washing process. It should be remembered that extreme changes of heat and cold shrink wool appreciably. It is for this reason that cold water should not be used as a final rinse. A good grade neutral soap should be used to make a very high suds. Do not use soda unless the garments are badly soiled or unless the water is of 10 grains or more hardness. In such a case, dissolve in water a mixture of 3 parts of 88% neutral soap and 1 part of soda ash. Never use Javel water for bleaching wool. A high water level should be used to avoid excessive pounding in the wheel. There is little doubt that it is this self same pounding which shrinks wool to such an extent. It also should be remembered that the fulling or milling process employed in textile mills makes use of a combination of heat, moisture, soap and alkali, and pressure. This is imitated in the wheel during washing, pressure being the result of the material rising with the wheel and falling back into the suds or rinse. If the water level is low, the pounding effect is correspondingly great.

When drying woolens, great care must be taken. If placed in the tumblers, such material should never be

dried to bone dryness, for excessive tumbling at a high temperature shrinks wool fully as much as the pounding action which may be received in the wheel. Remove woolens from the tumbler or dry room before they are quite dry and finish them on a press or dry at room temperature. If allowed to dry to bone dryness, woolens are very likely to become harsh and to lose their original softness.

In conclusion, it must be said that the points which the laundryowner should watch closely are water level in the wheel and drying. Needless to say, a high suds should be used. Heavily quilted articles and other cotton garments having the same texture and finish as cotton blankets should be handled in the same way as woolens.

Formula for Washing Woolens

1st Bath.—8 inches of water in wheel; temperature, 100° F. Run the wheel and add neutral soap to make a high suds, then add a small load. Run 10 minutes.

2nd Bath.—Stop wheel. Flood load with warm water; run 1 minute.

3rd Bath.—Repeat.

4th Bath.—Again stop the wheel and flood the load with warm water. Dump and draw the load.

NOTE:—In the case of extremely soiled woolens is often advisable to add 1 oz. of soda ash, 2 oz. of neutral soda, or trisodium phosphate, or 4 oz. of borax. Repeat the first bath if necessary.

Knit Underwear.—Wash according to the same procedure as for woolen goods. In case the goods are badly soiled, an additional suds will be required. If the underwear consists entirely of cotton, it will do no harm to add a small amount of soda ash to the wheel along with the soap. Part wool or all wool suits should be washed carefully and care taken with regard to drying in the tumbler.

Colored Socks

1st Bath.—Lukewarm water, 3 inches on the inside cylinder. Stock soap solution sufficient for a copious suds. In general, it is best

to have a thick suds when washing goods wherein dyes tend to run. Run 25 minutes.

2nd Bath.—Lukewarm water to half cover the goods (do not float them). Run 5 minutes.

3rd Bath.—Repeat.

4th Bath.—Repeat.

Feather Pillows.—Feather pillows may be successfully washed according to the procedure outlined for the cleaning of woolens. The pillow should be placed in a closely woven net, so that the feathers may be saved in case the covering breaks.

Silk.—Under this classification is included such a variety of articles as well as values that specific directions are beyond the scope of this book. It is obvious that great care must be exercised if the best results are to be obtained.

While it is desirable, if the volume of work requiring similar treatment justifies such a procedure, to handle this class of material in rotary machines of small diameter or in the vacuum-cup type of machines, it is not possible to give definite formulas that are applicable to all cases.

As is the case with wool, the temperature should be controlled carefully; 100° F. is sufficiently high. A good grade of soap containing no free alkali is especially required, since alkali will ruin silk if present in appreciable quantities. Colored silks should be washed quickly in order that the colors may not run. Silk should never be twisted or wrung, as it makes the smooth silk threads slip over one another, giving a wavy appearance. Avoid excess heat in any form. Silks should never be sprinkled before pressing, as the water makes them spotty, a defect that can be remedied only by relaundering. Silk fabrics should be pressed on the wrong side while they are still damp. Needless to say, no attempt should ever be made to bleach silk, since the chlorine bleach yellows the sensitive fibers. Artificial silk garments should be laundered

as if they were natural silk. Great care should be taken when washing garments containing artificial silk, due to the fact that, when wet, artificial silk has but one-quarter to one-third the strength that it possesses when dry.

Material consisting of part silk and part cotton or linen should be laundered as if all silk. Sorters should be instructed to watch carefully for such types of material in shirts, underwear and pajamas. Lightweight garments in particular should be examined closely, as in many cases they contain a natural or artificial silk filling.

Curtains.—Curtains, as a rule, when soiled, hold the dirt loosely and hence do not require a drastic wash to get them clean. They should be examined carefully before being sent to the wash room and measurements with regard to the length and width taken. If any curtains appear at all weak or if it is doubtful that they will withstand a light soap treatment, the laundryowner should notify the customer that he will launder them only at the customer's risk. It is well known that sunlight attacks curtains when they are exposed to it for a great length of time, weakening them often to a great extent. Curtains should always be washed in nets. Judgment must be used with regard to starching, since a scrim curtain, for example, needs very little starch, whereas a heavy lace curtain requires a great deal.

White Curtains

1st Bath.—100° F., 5 inches of water, soap and soda. Run 5 minutes.

2nd Bath.—120° F., 5 inches of water, soap and soda. Run 10 minutes.

3rd Bath.—120° F., 5 inches of water, soap and soda, slight quantuty of bleach if necessary. Run 10 minutes.

4th Bath.—120° F., 10 inches of water. Run 5 minutes.

5th Bath.—120° F., 10 inches of water, sour and blue if necessary. Run 5 minutes.

6th Bath.—Cold, 10 inches of water. Run 5 minutes.

NOTE:—Unless the curtains are badly soiled, two suds will be sufficient. Eliminate the third bath.

Ecru and Colored Curtains

1st Bath.—100° F., 5 inches of water, soap. Run 5 minutes.
2nd Bath.—100° F., 5 inches of water, soap. Run 10 minutes.
3rd Bath.—Repeat.
4th Bath.—100° F., 10 inches of water. Run 5 minutes.
5th Bath.—Repeat.
6th Bath.—Cold, 10 inches of water. Run 5 minutes.

NOTE:—Two suds will be found sufficient unless the curtains are badly soiled. Eliminate the third bath.

For Laundry purposes the use of Sodium Acid Fluoride and other Flourine Compounds having acid reactions is patented. Patent No. 1,016,928 of Feb. 13, 1912. Owned by A. W. Wilkinson and H. B. Bishop.

CHAPTER XIII

SANITARY CONDITION OF POWER-LAUNDRY OUTPUT

This question has been presented before laundry-owners on so many occasions that its repetition at this time might appear, casually, to be unnecessary. It has, however, required so much consideration by the Department of Research, and is, moreover, of such constant importance that a brief statement of the findings on this subject to date seems to be desirable.

The temperature of the washing bath, 180° F. or more, for fifteen minutes, is sufficient to kill the hardiest of bacteria. Then, too, soap solutions, even at temperatures as low as 104° F. to 120° F. have a real value for killing bacteria.

Bleach liquor of the strength usually employed in the power-laundry process is an excellent sterilizing agent. In fact, as before stated in this report, Javel water is the antiseptic that was so successfully employed in the treatment of wounds in the World War.

Moreover, the temperatures of the flat-work ironer, the garment-press, shirt- and collar-ironers, the hot-air tumbler, and the drying-forms for socks and stockings are sufficient to kill any disease-producing germs ("pathogens").

These facts have been firmly established, not only by the work of this Department, but also by the published reports of other investigators.

In the February 9, 1917, issue of the *Public Health Reports*, published by the United States Public Health Service, there appeared a paper on one of the recent investi-

gations of this subject, being a report of work carried on in New York City. The authors of this contribution confirmed all the statements made above, except the ones regarding bleach liquor and soap. In fact, there was very little presented in their report that reflected upon, or even pertained to, the better class of power laundries; but a very misleading account of the conclusions appeared in the public press.

The authors of the paper cited were, according to best authority, incorrect in their conclusions respecting bleach liquor; and the work of this Department has proved that they were misled in their conclusions regarding soap, because their experiments were made under conditions unlike those prevailing in practice, principally in omitting the effect of agitation along with the effect of the soap itself.

A noteworthy indorsement of our conclusions in this regard is to be found in the statement of Dr. Ira S. Wile, writing in the *Medical News* (New York), wherein he concludes a discussion of laundry hygiene by saying that in the usual laundry process "exposure to heat and the usual washing reagents along with mechanical agitation destroy the hardiest of bacteria," and that "laundering appears to be an efficient hygienic method of promoting cleanliness without danger to patron and with comparative safety for the employee. This cannot be said of the laundress who takes in washing."

The following statement by Dr. J. H. Schereschewsky, of the U. S. Public Health Service, is also of interest in this connection. He says: "As far as the patron is concerned, the power laundry is not likely to communicate disease and it is very unlikely (though not at all impossible) that disease may be communicated to checkers (markers) by means of contaminated linens. For the part of the patron the precaution of prime importance is

that bundles of finished work should not be made up on the same tables that are used for checking (marking) the soiled linen—preferably the work should be done in different rooms. For the checker (marker), the first precaution is to keep the hands in good shape and have any abrasions of the skin protected."

In the preparation of the formulas presented in Chapter XII, the matter of sanitation is automatically cared for in the case of every class of goods requiring washing in the power laundry. However, it is appropriate to emphasize a few points.

In washing woolens do not be sparing with the soap. To make assurance doubly sure, woolen body-garments should be ironed or pressed, and, above all, goods should be sorted and bundled in a clean place as remote from the marking department as possible and preferably in a separate room.

Some public investigators of laundry sanitation have from time to time raised objections against the practice of collecting soiled linen at the same time that clean linen is being delivered, or in the same wagon that is being used for delivering clean linen. It would seem that this objection is not well founded, provided the clean linen is securely packed and bundled. In order to forestall any possible criticism in this regard, it might prove a worthy suggestion to provide separate baskets or separate compartments of the wagon, in order to prevent any possible infection of the laundered goods through contact with soiled linen.

Bactericidal Value of the Laundry Wash-Wheel.—Dr. G. F. White[1] has compiled for use the following data on the effects of temperature on bacteria:

"The approximate thermal death point of representative pathogenic non-spore-bearing bacteria is as follows:

[1]Part of a report prepared for the Laundry Branch of the Quartermaster's Corps of the U. S. Army.

Streptococcus	131° F. maintained for 10 min.
Micrococcus	140° F. maintained for 10 min.
Bacterium diphtheriae	140° F. maintained for 10 min.
Bacterium mallei (glanders)	140° F. maintained for 10 min.
Bacterium influensae	140° F. maintained for 5 min.
Bacterium tuberculosis	140° F. maintained for 20 min.
Bacillus typhosus	136.4-140° F. maintained for 10 min.
Bacillus coli	140° F. maintained for 5-15 min.
Spirillum cholerae	140° F. maintained for 10 min.

"Under laboratory conditions, therefore, 140° F. (60° C.) maintained for twenty minutes is sufficient to destroy the foregoing species. What is true for them is true for most, if not all, of the non-spore-bearing pathogenic forms. Tests are usually made with the organisms in bouillon or normal salt solution. For practical purposes it may be considered that in water the thermal death point would be the same as recorded in the list.

"The amount of heating necessary to destroy the non-spore-bearing pathogenic species in milk may be given as follows: 140° F. for 30 minutes; 149° F. for 20 minutes; or 158° F. for five minutes. Any of the three combinations may be used in pasteurization and the fact gives some information of value in laundry problems.

"Protozoa are destroyed with approximately an equal amount of heating. Data are rather scarce. Encysted amebae have withstood 140° F. for one hour but are usually destroyed. Nosema apisin in the spore form is destroyed at 136.4 F. for ten minutes.

"In the filterable viruses destruction is accomplished by approximately the same amount of heating as in the bacteria. Yellow fever virus succumbs at 131° F. in five minutes; rabies virus at 140° F. in one hour; foot and mouth disease at 140° F. in ten minutes; and sacbrood virus at 139° F. in ten minutes.

"Spore-bearing bacteria also are destroyed by the action of temperature. Some are killed during the time the temperature is raised to a boil, while others require a boil-

ing temperature for twenty minutes, half an hour or even longer.

"Variations in the thermal death-point are to be expected and do occur in instances in which the resistance to heating is considerably increased above that indicated by the above figures. In practical work generally, these are not considered.

"As a working basis, therefore, in laundry problems, a temperature of from 140° F. to 158° F. maintained for twenty minutes would be amply sufficient to destroy all pathogenic non-spore-bearing forms. It should be added that the vessel should be a closed one. The temperature and time actually required would depend somewhat upon the care with which the work was done."

Such laundries as have adopted the L. N. A. Standard Formulas for washroom practice, and wherein the precautions above mentioned are being observed, have the indorsement of Mellon Institute of Industrial Research as to the sanitary condition of their output.

References:

"On the Bactericidal Efficiency of Soap Solution in the Power Laundry," by Elledge and McBride, *American Journal of Public Health*, July, **1918**, pages 494-498; "The Bacterial Action of Dry Cleaning," Lloyd E. Jackson, *American Journal of Public Health*, June, **1922**.

CHATER XIV

ON THE CARE OF METAL WASHING MACHINES

While the formulas discussed in the preceding chapters have been prepared, as stated, for the usual construction of wooden washing-machines and will, therefore, require some slight modification as to time to adapt them to the newer types of quick-rinsing metal machines, the important principles set forth herein, such as the sequence of baths, soda rinse, method of bleaching, etc., as well as the reagents specified, apply with equal force in the operation of this newer type of equipment.

In these formulas there are cleansing materials called for that are more or less corrosive to any of the metals or alloys that are commercially available at anything like a reasonable price. Javel water is a strong oxidizing material and even in the dilute concentration, which we have found to be safe to use as far as the welfare of the fabrics being washed is concerned, it has some effect on brass and a decided effect on zinc (galvanized surfaces) and iron. For instance, we found by a laboratory test, which engineers describe as an accelerated test, that a solution of Javel water of the strength of one part of available chlorine in 10,000 parts of water, the concentration recommended in Chapter XII. would eat away one-half the thickness of the embossed brass used in the construction of the inner cylinder of the quick-rinsing type of machine in a period of 28.5 years of continuous exposure to such a solution. That is, as you see, not very alarming because the metal would not be exposed to this

bath more than 150 minutes a day. If no other deteriorating factor were in force the cylinder would last 270 years. The use of a stronger solution, however, would cause a depreciation of the order that would give the owner of the equipment some concern.

It is not alone this reagent that has to be considered. Caustic soda, which, it is hoped, few laundries are now using, and oxalic acid (if used excessively), both working in conjunction with the Javel water, one after the other, make a depreciation rate much greater than the sum of the effects of each acting alone.

With the reagents and quantities specified in Chapter XII, the chemical effect (on the life of the machine) is slight compared with the abrasive effect of the water-laden fabrics and of the buttons. The results of our tests are mentioned to emphasize the possibility of abusing a brass cylinder as well as the fabrics being treated by using certain washing reagents in excess.

Some of the types of machines, however, have galvanized iron parts, especially a galvanized iron shell. Galvanized iron is simply iron, the surface of which has been coated with a thin film of zinc. With zinc the story is one quite different from that of brass. Zinc is quite readily dissolved by caustic soda solutions. Soda ash or "neutral sodas" attack it to an appreciable extent in hot water. Javel water has a more decided action on it and even so weak an acid as acetic acid will dissolve zinc quite readily. In fact, the zinc disappears from the galvanized surfaces of washing machine parts in the course of a very few weeks, leaving the iron exposed. Iron rusts quite readily when alternately exposed to air and water, which is the condition in the washing machine. If the coating of rust is not disturbed it will afford some measure of protection, the extent of the protection depending on the quality of the iron. If, on the other

hand, the coating of iron oxide (the rust) is removed, more forms at the expense of more iron and the thickness of the metal is progressively reduced.

One of the best solvents for rust is oxalic acid. One of the best oxidizers or rust producers in the case of iron is Javel water. Therefore, in the use of the white shirt and collar formula, in Chapter XII, there is the ideal combination for the rapid deterioration of a galvanized shell. The soda, bleach, and sour soon dissolve the zinc. The air and water and Javel water accelerate the rusting of the iron. The sour, if it is all or in part oxalic acid, one of the acid salts of fluorine or sodium bisulfite. dissolves the rust and the cycle is repeated every time a load of goods is washed. In consequence of this set of facts, it is the advice of this Department that a metal washer should be of brass, or preferably of monel metal or "ambrac," throughout (shell and all), if Javel water and oxalic acid are to be used in it. If a metal machine having a galvanized iron shell is already installed for washing the class of goods requiring the white shirt and collar formula, its period of service may be prolonged by using acetic acid only as a sour.

Some readers will be inclined to accept the foregoing statements and conclusions with reservation, because there are many old machines with iron shells in use at the present time that have been in service ten, fifteen or even twenty years. Investigation shows, however, that these apparent exceptions are not exceptions at all. These machines, it will be found, are in plants wherein moderately hard water or water softened by means of the soda ash-lime system has been used. In such cases the iron surfaces have been protected by the coatings of lime soap that are already present on the interior surfaces of machines in which hard water has been used. If these installations had been in plants using water from zeolite softeners, the history of many of them would not be obtainable.

Summary.—The all-brass machines, even in laundries wherein water of zero hardness is used, will withstand any of the reagents recommended in Chapter XII, **provided the advice as to the quantities to be used is faithfully followed.** That is to say, they will render a satisfactory period of service in laundries wherein the conservation of the patrons' goods is a matter of consideration. Ammonia should not be used in them. Mineral acid should be avoided and Javel water and oxalic acid should not be used in excessive quantities. The welfare of the patrons' goods, as well as that of the machine, demands these precautions. The formation of "verdigris" cannot be avoided in all-brass machines. **But the staining which may occur when it contaminates the bath, may be prevented by a thorough cleansing of the metal surfaces once each week.** All-brass machines may be cleaned by the use of a 5% (by volume) solution of either hydrochloric or, preferably, sulfuric acid. The acid solution should be run into the machine and kept in contact with the interior surface until the "verdigris" is entirely removed; it should then be followed by a 1% solution of soda ash, and finally by a rinse of water.

For those machines having galvanized-iron shells the same provisions as for the all-brass ones are demanded together with the additional safety requirement that no sour other than acetic acid should be used in them if the water supply is of zero hardness.

Monel metal or "ambrac" machines require little or no cleaning when washing is properly done in them. The new machine, as it comes from the factory, always requires treatment for the removal of grease and oil and the directions for accomplishing this are furnished along with the machine.

Reference:

"Metal Washer Construction," J. N. Vermilya, *Starchroom Laundry Journal*, Dec. 15, 1923.

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